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Maternal and Child Outcomes Associated with the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of systematic reviews to assist public- and private-sector organizations in their efforts to improve the quality of healthcare in the United States. These reviews provide comprehensive, science-based information on common, costly medical conditions, and new healthcare technologies and strategies.

Systematic reviews are the building blocks underlying evidence-based practice; they focus attention on the strength and limits of evidence from research studies about the effectiveness and safety of a clinical intervention. In the context of developing recommendations for practice, systematic reviews can help clarify whether assertions about the value of the intervention are based on strong evidence from clinical studies. For more information about AHRQ EPC systematic reviews, see www.effectivehealthcare.ahrq.gov/reference/purpose.cfm

AHRQ expects that these systematic reviews will be helpful to health plans, providers, purchasers, government programs, and the healthcare system as a whole. Transparency and stakeholder input are essential to the Effective Health Care Program. Please visit the website (www.effectivehealthcare.ahrq.gov) to see draft research questions and reports or to join an e-mail list to learn about new program products and opportunities for input.

If you have comments on this systematic review, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

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Technical Expert Panel

In designing the study questions and methodology at the outset of this report, the EPC consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicted opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

Technical Experts must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential conflicts of interest identified.

The list of Technical Experts who provided input to this report follows:

To be included in the final report.

Peer Reviewers

Prior to publication of the final evidence report, EPCs sought input from independent Peer Reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report do not necessarily represent the views of individual reviewers.

Peer Reviewers must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential non-financial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential non-financial conflicts of interest identified.

The list of Peer Reviewers follows:

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Maternal and Child Outcomes Associated with the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)

Structured Abstract

Objectives. The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) aims to safeguard the health of low-income, nutritionally at risk pregnant and postpartum women and children less than five years old. This systematic review evaluates evidence on whether participation in WIC is associated with nutrition and health outcomes for women, infants, and children, and whether the associations vary by duration of participation or across population sub-groups (e.g., race, ethnicity, age). Because of major revisions to the Federal regulations for the WIC food package in 2009, we prioritized studies published since 2009 and included studies comparing outcomes before and after the 2009 food package change.

Data sources. Using electronic publication databases, hand searching, and websites, we conducted a literature search from January 2009 to September 2020 and a targeted search for selected outcomes from January 2000 to September 2020.

Review methods. Two reviewers independently screened search results, serially abstracted data, assessed risk of bias, and graded strength of evidence (SOE) using standard methods for observational studies.

Results. We included 77 quantitative observational studies and 16 qualitative studies, with 44 studies comparing outcomes of WIC participants with eligible non-WIC participants. WIC prenatal participation was associated with lower risk of preterm delivery (low SOE), lower risk of low birth weight (low SOE) and lower risk of infant mortality (low SOE). Maternal WIC participation was associated with higher cognitive scores for children (low SOE). Child WIC participation was associated with improved diet quality (moderate SOE) and greater intakes of 100 percent fruit juice, infant cereal/grains, and age-appropriate shifts from whole milk to low-fat milk (SOE: Moderate). Household WIC participation was associated with purchasing foods of better diet quality (moderate SOE). Maternal WIC participation was not associated with breastfeeding initiation (low SOE). The evidence was insufficient regarding WIC participation and outcomes related to maternal diet and health, child anthropometric status, and child health care utilization. The evidence was insufficient to determine how WIC participation affects outcomes across participant sub-groups.

Conclusions. Maternal WIC participation was associated with improved birth outcomes, lower infant mortality, and better child cognitive development. Child WIC participation was associated with improved diet quality. Household WIC participation was associated with purchasing foods of better diet quality. More research is needed to determine the effectiveness of WIC for all outcomes and in all segments of the eligible population.

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Evidence Summary

Main Points

Maternal and Infant Birth Outcomes

- Maternal WIC participation during pregnancy may be associated with lower risk of preterm birth (Strength of evidence [SOE]: Low).
- Maternal WIC participation during pregnancy may be associated with lower risk of low birth weight infants (SOE: Low).
- The evidence was insufficient to determine whether maternal WIC participation was associated with gestational diabetes, preeclampsia, gestational hypertension, stillbirth, neonatal death, or neonatal intensive care unit (NICU) stays (SOE: Insufficient).

Maternal Dietary Outcomes

- The evidence was insufficient to determine whether maternal WIC participation during pregnancy was associated with better maternal diet quality or food/nutrient intakes (SOE: Insufficient).

Infant and Child Health Outcomes

- Maternal WIC participation during pregnancy may be associated with reductions in infant mortality (SOE: Low).
- The evidence was insufficient to determine whether either maternal or child participation was associated with child health outcomes (including child mortality, morbidity, and preventive care receipt) (SOE: Insufficient).

Child Anthropometric Status or Growth

- The evidence was insufficient to determine whether child WIC participation was associated with overweight or obesity in children (SOE: Insufficient).

Breastfeeding Outcomes

- Maternal WIC participation may not be associated with breastfeeding initiation rate (SOE: Low)
- The evidence was insufficient to determine whether maternal or child WIC participation was associated with longer duration of breastfeeding, breastfeeding exclusivity, or introduction of solids before 4 months of age (SOE: Insufficient).

Child Dietary Outcomes

- Child WIC participation is likely to be associated with better child diet quality (SOE: Moderate).
- Child WIC participation is likely to be associated with greater intakes of 100 percent fruit juice, vegetables, infant cereal/grains, and age-appropriate shifts from whole milk to lower fat milk (SOE: Moderate).
- Household participation in WIC is likely to be associated with purchasing food of better diet quality and reduced purchasing of less healthy foods (SOE: Moderate).
- The evidence was insufficient to determine whether child WIC participation was associated with better nutrient intakes or whether living in a WIC household was associated with diet quality or food/nutrient intakes in women (SOE: Insufficient).

Child Development and Academic Achievement

- Maternal WIC participation may be associated with higher cognitive development scores in early childhood (SOE: Low).

- The evidence was insufficient to determine whether child WIC participation was associated with cognitive development or whether maternal or child WIC participation was associated with other child development outcomes (SOE: Insufficient).

Background and Purpose

WIC was established to improve the health of low-income women and children by providing nutritious supplemental foods, education, breastfeeding support, and referrals to health and social service programs. This systematic review summarizes evidence on whether participation in WIC was associated with outcomes for women and children, focusing mainly on studies published since 2009, including studies evaluating outcomes of WIC participants before and after the Federal policy change to the WIC food package in 2009. The Key Questions and outcomes addressed in this review are listed below.

- **Key Question 1: Among women who are eligible to participate in WIC, how is WIC participation during pregnancy associated with maternal and infant birth outcomes? Does the association vary by gestational age at WIC enrollment or duration of the mother's WIC participation or participant factors?**

  Outcomes: Maternal health outcomes in pregnancy and postpartum (mortality, morbidity, anemia, mode of delivery, weight status, healthcare utilization, health behaviors), infant birth outcomes (fetal death, stillbirth and neonatal mortality, gestational age, birth weight, small/large for gestational age, NICU admission, hospital length of stay), breastfeeding, dietary outcomes of mothers

- **Key Question 2: Among infants and children eligible to participate in WIC, how is WIC participation associated with dietary and health outcomes in childhood? Does the association vary by age at enrollment or duration of WIC participation or participant factors?**

  Outcomes: Infant and child health outcomes (mortality, morbidity, anemia, healthcare utilization), child anthropometric status or growth outcomes, breastfeeding, dietary outcomes of infants and children, household purchases and benefit redemption, child development and academic achievement

Methods

The systematic review followed the Methods Guide for Effectiveness and Comparative Effectiveness Reviews (https://effectivehealthcare.ahrq.gov/topics/cer-methods-guide/overview). We searched PubMed, Embase®, CINAHL, ERIC, SCOPUS, PsycINFO, and the Cochrane Central Register of Controlled Trials for studies of outcomes associated with WIC participation, focusing on participation after the 2009 food package change and comparison to WIC-eligible non-participants. We conducted one search from January 2009 to September 2020 and another search for selected outcomes (infant mortality, maternal mortality, and child development and academic achievement) from January 2000 to September 2020. We also completed a grey literature search. Two reviewers independently screened citations. Data were abstracted by one reviewer and checked by an experienced reviewer. See the full report for details

Results

We found 77 quantitative observational studies and 16 qualitative studies. Forty-four studies provided direct evidence regarding WIC participation and outcomes, 32 studies provided indirect evidence based on evaluation of the 2009 food package change among WIC participants, and 1 study provided both direct and indirect evidence. Table A summarizes direct evidence regarding WIC participation and outcomes. If a prespecified outcome is not listed in the table that means no study reported on that outcome. The full report provides more details.

Table A. Summary of the direct evidence regarding association between WIC participation and outcomes

Outcomes	Evidence on association between WIC participation and outcomes	Insufficient evidence despite one or more studies
Maternal health outcomes (KQ1)		• Gestational weight gain (1 study)
Neonatal and infant birth outcomes (KQ1)	**May be associated (Low SOE)** • Less preterm birth (3 studies) • Less infant low birth weight (3 studies)	• Fetal death, stillbirth and neonatal mortality (1 study) • NICU admission and hospital length of stay (1 study)
Maternal dietary outcomes (KQ1)		• Diet quality of pregnant/ postpartum WIC participants (1 study) • Food group and nutrient intakes of pregnant/ postpartum WIC participants (1 study)
Infant and child health outcomes (KQ2)	**May be associated (Low SOE)** • Lower infant mortality (2 studies)	• Morbidity -health status, hospitalization (1 study) • Health care utilization -preventive care visits (1 study) • Health care utilization- immunizations (maternal WIC 1 study) (child WIC 2 studies)
Child growth anthropometric status (KQ2)		• Child weight status, overweight and obesity (1 study) • Z-scores of length, height, weight or weight-for-length/height –(maternal 1 study) (child 1 study)
Breastfeeding outcomes (KQ1 & KQ2)	**May <u>not</u> be associated (Low SOE)** • Breastfeeding initiation (4 studies)	• Breastfeeding duration (2 studies) • Breastfeeding exclusivity (1 study) • Introduction of solids before 4 months (1 study)
Child dietary outcomes (KQ2)	**Likely to be associated (Moderate SOE)** • Child higher diet quality (2 studies) • Child higher healthy food group intake (3 studies) • Household purchasing of healthy food groups (6 studies)	• Child nutrient intakes (1 study) • Diet quality/ food group/ nutrient intakes in WIC households (1 study)
Child development and academic achievement (KQ2)	**May be associated (Low SOE)** • Maternal participation and better child cognitive development (2 studies)	• Child participation and cognitive development (1 study) • Social development (1 study) • Motor development (1 study) • Communication and adaptive behavior (maternal WIC 1 study) (child WIC 1 study) • Developmental risk (1 study) • Academic achievement (1 study)

KQ= Key Questions; NICU = neonatal intensive care unit; SOE = Strength of evidence; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children

Strengths and Limitations

This is the first systematic review to address the association of WIC participation with such a wide range of maternal and child outcomes. We also considered evidence on how these outcomes were associated with the 2009 food package change which is indirect evidence on the key question of WIC participation. The evidence spans most of the United States, and uses federal and state surveillance systems, vital statistics, federal studies, and investigator-initiated studies. None of the evidence came from randomized trials, and this led to no findings of high SOE. All studies used covariate adjustment to address confounding, and many used innovative design or analytic methods to reduce risk of bias. In general, WIC participation was self-reported with little detail about benefit issuance or duration of participation. Conclusions must balance evidence across studies with varying risk of bias. We did not use meta-analysis to synthesize findings because of the heterogeneity of study designs, populations, comparisons, and outcome measures. Despite the large number of studies, for many outcomes only a few studies were identified. None of the studies reported on maternal mortality, maternal anemia, or food security, and insufficient SOE was found for many outcomes. Finally, few studies addressed whether the association of WIC participation with improved outcomes varied by maternal age, race/ethnicity, geographic location, education, employment status, marital status, or housing.

Implications and Conclusions

The review provides important findings regarding maternal WIC participation, improved birth outcomes, lower infant mortality, and higher child cognitive development. Child WIC participation was associated with improved dietary patterns and overall diet quality, and with household purchases of quality food groups suggesting improved dietary patterns. The evidence suggests no association between maternal WIC participation and breastfeeding initiation. The evidence is insufficient regarding WIC participation and child overweight or obesity, but surveillance data indicate that exposure to the 2009 revised food package may help lower the risk of overweight and obesity for participating children. For policy makers at state and federal levels, the review summarizes the current evidence base for considering changes to the WIC Program to further improve outcomes. For policy makers and researchers, the review highlights gaps which require new studies, including: the spectrum of maternal health outcomes associated with maternal WIC participation; WIC participation and food security; maternal and/or child WIC and child development outcomes; child WIC participation and high weight status; and maternal or child participation and healthcare outcomes for children.

Introduction

The WIC Program

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was established in 1974 to safeguard the health of low-income women, infants, and children younger than five years of age who are at nutritional risk, by providing nutritious supplemental foods, nutrition education, breastfeeding support, and referrals to other health and social service programs. WIC is administered by the U.S. Department of Agriculture (USDA) Food and Nutrition Service (FNS) through 90 State agencies and, in 2020, provided benefits to 6.2 million people.[1]

To be eligible for WIC, a woman must be pregnant or postpartum. Women who are postpartum are eligible for up to 12 months if they are breastfeeding and 6 months if they are not breastfeeding. Infants (< 12 months of age) and children 1 to 4 years of age are also eligible. Applicants must be considered "at nutritional risk"[2] and have household income less than or equal to 185 percent of the Federal Poverty Guidelines issued annually by the U.S. Department of Health and Human Services. Applicants may also be adjunctively income-eligible for WIC if they participate in Medicaid, the Supplemental Nutrition Assistance Program (SNAP), or Temporary Assistance for Needy Families (TANF). Applicants must live in the State or Territory in which they apply or meet residency requirements established by an Indian Tribal Organization (ITO). In 2018, 11.9 million people in the United States were estimated to be eligible to receive WIC benefits; program coverage (those receiving benefits of those eligible) was 53 percent for pregnant women, 84 percent for postpartum women, and 98 percent for infants. Coverage for children declined with their age (61%, 48%, 41% and 27%, respectively, for children 1, 2, 3 and 4 years of age).[3] Given the current reach of the WIC program and the even larger pool of eligible women and children, it is important to understand both the current impact of participation on outcomes for women and children and the potential impact if coverage rates increase.

Evaluations of WIC

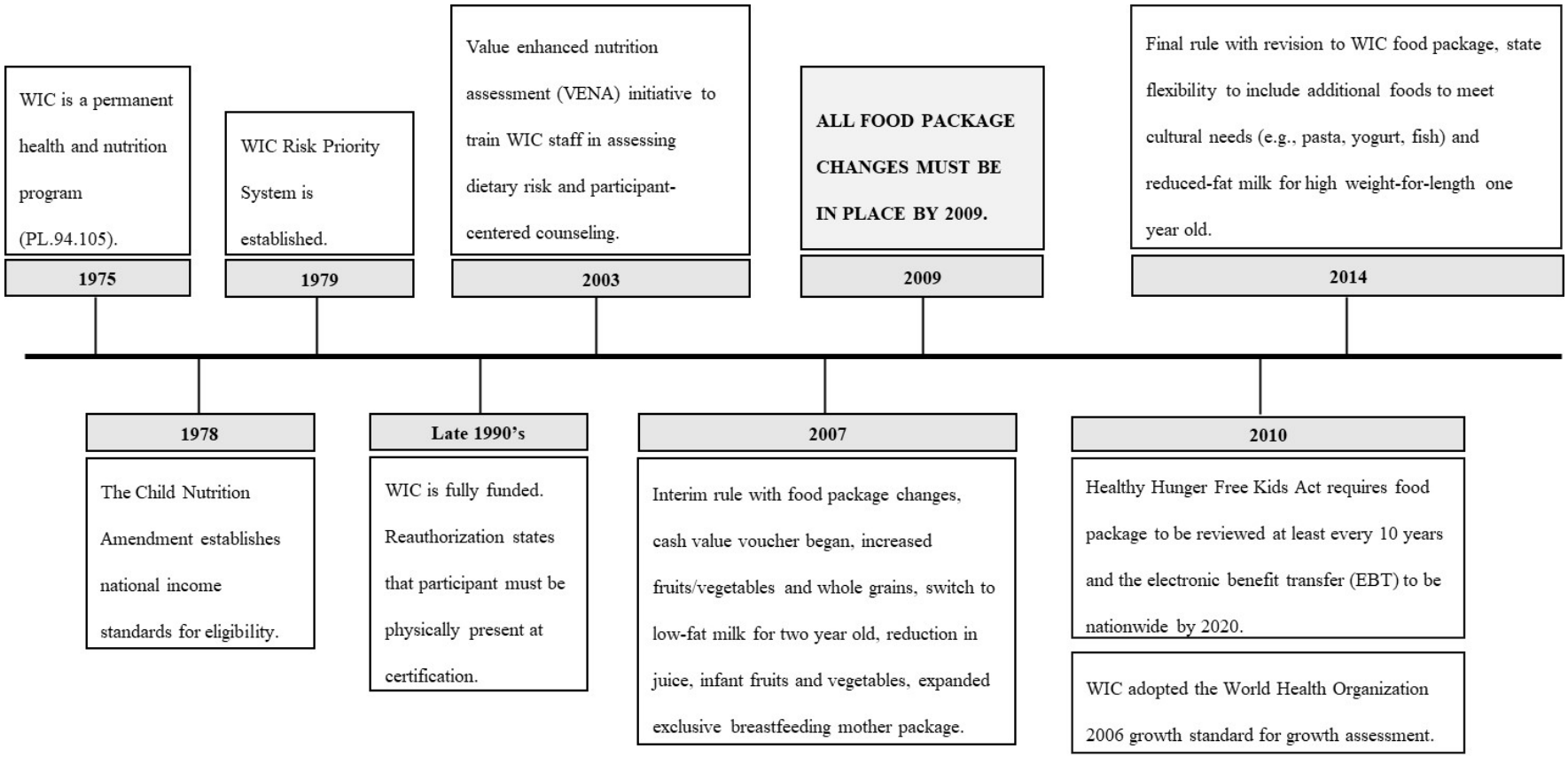
Since its inception in 1974, the WIC Program has evolved to better and more efficiently address program goals and maintain consistency with the latest health and nutritional guidelines (Figure 1). WIC has been the subject of numerous studies of its impact on maternal and child outcomes. In 2004, USDA published a review of the effectiveness of WIC, as one of several Federal assistance programs, and included published studies from the 1970s through 2002.[4] A second review, published by USDA in 2012, included published studies from 2002 to 2010 and unpublished studies from 1999 to 2002 (i.e., going beyond the 2004 review[4]), while also explicitly evaluating the quality of the evidence.[5] That second review found evidence that WIC participation was associated with improved birth outcomes and child diet quality. The review also identified weaker quality evidence, subject to selection bias, suggesting that WIC participation may be associated with a lower likelihood of breastfeeding and described mixed findings on infant or child anthropometric outcomes (e.g., weight-for age, length-for-age, overweight, failure-to-thrive). The 2012 review also found that no clear conclusions could be drawn with respect to outcomes for child health and development.

The 2012 review explicitly focused on evaluation of outcomes for a period of time prior to the 2009 change in the WIC food package (hereafter referred to as the 2009 food package change).[5] The 2009 food package change was the first major change in the WIC food package

and was designed to strengthen promotion and support of breastfeeding, improved diet quality, and child obesity prevention.[6] The 2009 food package change aligned with recommendations from the National Academies of Sciences, Engineering, and Medicine (NASEM) review of the WIC food package,[7] the American Academy of Pediatrics (AAP) recommendations regarding infant feeding,[8] and the 2005 Dietary Guidelines for Americans (DGA)[9] for chronic disease prevention. The revised food package included several changes: 1) added fruits and infant food meats, more vegetables, whole grains, a switch to low-fat milk (at age 2 years), and reductions in the amount of 100 percent juice; 2) adjusted amounts of infant formula by proportion of human milk provided by breastfeeding to infants; 3) changes in package provisions for postpartum women by breastfeeding status, with fully breastfeeding (i.e., no infant formula) mothers receiving the largest package, in terms of quantity and variety. Since 2009, new studies have evaluated outcomes for women, infants, and children associated with WIC participation and compared differences in outcomes before versus after the 2009 food package change.

In 2020, the *Dietary Guidelines for Americans, 2020–2025* was released and included new guidelines for nutritional intake for women during pregnancy and lactation, and children from birth to 24 months of age.[10] The Healthy Hunger Free Kids Act of 2010 stipulated that that the food package be reviewed every 10 years.[11] It is thus time to re-evaluate the evidence regarding WIC participation and the revised food package. Health care professionals, WIC and other public health practitioners, the research community, and WIC participants need reliable information about the effectiveness of WIC; and policymakers at the state and Federal levels need such information to determine whether changes should be made in WIC programming to further improve dietary and health outcomes for women, infants, and children.

Figure 1. WIC timeline with selected key program changes



EBT = electronic benefit transfer; PI = National Archive Preliminary Inventory; VENA = value enhanced nutrition assessment; WIC = Supplemental Nutrition Program for Women, Infants, and Children

Purpose and Scope of the Systematic Review

We synthesized recent (defined for most outcomes as inclusive of data from 2009 and later) evidence on whether WIC participation is associated with outcomes for women and children.

WIC is a Federal program administered in accordance with Federal regulations, and causal evidence of its impact through randomized controlled trials (RCTs) is absent. Thus, direct evidence on whether WIC participation is associated with outcomes comes from comparisons of WIC participants with WIC-eligible non-participants. Because eligible individuals may or may not choose to participate, selection bias should be addressed. The reasons given for individual participation and the duration of that participation are complex and only partially understood.[12-15]

In general, research suggests that WIC participation and retention are associated with greater disadvantage and food insecurity, although some evidence suggests that breastfeeding and the perception of being helped by WIC are each associated specifically with longer retention of children.[12-15] What this means is that observational studies are likely to be negatively biased if they do not either perform adequate adjustment for confounding or use approaches to enhance causal inference (e.g., matching, propensity scoring, regression discontinuity, instrumental variable, within-mother across siblings). Medicaid expansion has increased the number of pregnant women eligible for WIC (through adjunctive eligibility), which has changed the characteristics of prenatal WIC participants and WIC-eligible non-participants. As a result of those changes, the associations of maternal WIC participation with maternal and infant birth outcomes, as well as child outcomes, may have also changed. Although studies often identify WIC-eligible individuals based on adjunctive eligibility, the requirements for these programs exclude specific income-eligible sub-populations from the evidence base.

The 2009 food package change provided a natural experiment for evaluating outcomes by WIC participation across time periods with different food packages. The goal of this analysis was not to compare the food packages per se, but to evaluate WIC participation under the revised food package, adjusting for prior differences under the pre-2009 food package. Thus, studies that use difference in difference designs (and covariate adjustment) can provide direct evidence regarding the association between WIC participation and maternal and child outcomes. Studies may also compare outcomes before and after the 2009 food package change only among WIC participants. With appropriate covariate adjustment and matching or propensity scoring to address changes in the WIC population over time, studies evaluating outcomes associated with 2009 food package change in WIC participants can provide indirect evidence regarding the association between WIC participation and outcomes.

This review aims to describe the study designs and data sources used to evaluate maternal and child outcomes associated with WIC participation (including studies evaluating the 2009 food package change), evaluate the quality of evidence provided by these studies, and examine how studies characterized participation of women and/or children in WIC. The systematic review also seeks to identify evidence regarding dose or duration of participation, and differences in outcomes for sub-groups of women and children (e.g., age, race/ethnicity). The review also identifies evidence gaps to be addressed in future research.

Methods

Review Approach

We followed the methods outlined in the Agency for Healthcare Research and Quality's (AHRQ's) Methods Guide for Effectiveness and Comparative Effectiveness Reviews. This systematic review also reports on the methods and results in accordance with the Preferred Items for Reporting in Systematic Reviews and Meta-Analyses (PRISMA).[16]

The Key Questions for this systematic review were developed by the USDA FNS in consultation with AHRQ. We recruited a Technical Expert Panel (TEP) to review the protocol. The TEP included experts in nutrition and primary care and representatives of the WIC program and government organizations. With feedback from the TEP, USDA, and AHRQ, we finalized the protocol and posted it on the AHRQ Effective Health Care Program's website (www.effectivehealthcare.ahrq.gov) and registered with the PROSPERO registry (CRD42020222452).

Key Questions

Key Question 1: Among women who are eligible to participate in WIC, how is WIC participation during pregnancy associated with maternal and infant birth outcomes?

a. Does the association of maternal and infant outcomes with WIC vary by gestational age at WIC enrollment or duration of the mother's WIC participation?
b. Does the association of maternal and infant health outcomes with WIC vary by participant factors such as age of the mother at delivery, race/ethnicity of mother, geographic location (e.g., region, urban vs. rural), education of the mother, employment status of the mother, marital status, or housing (e.g., public, homeless)?

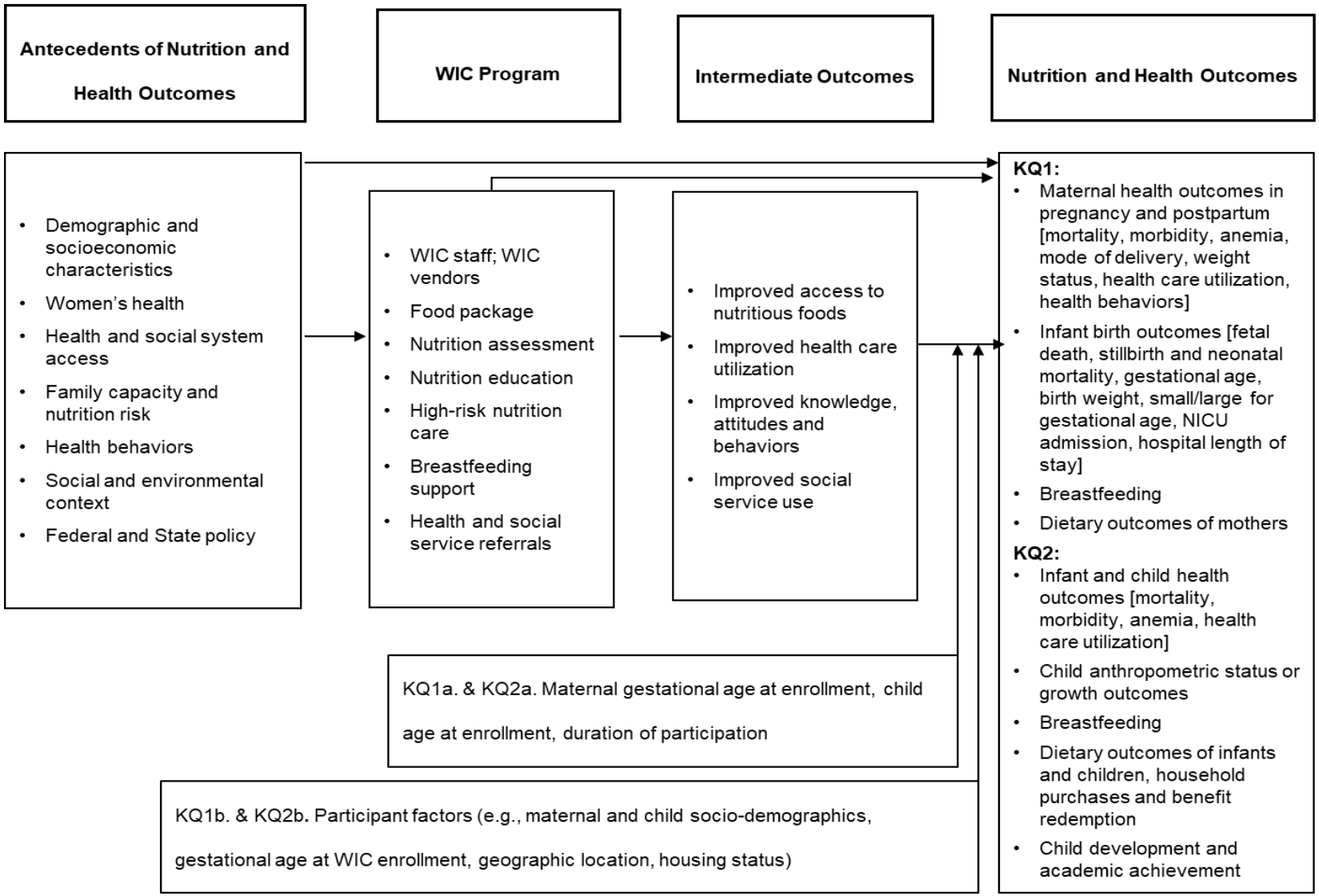
Key Question 2: Among infants and children eligible to participate in WIC, how is WIC participation associated with dietary and health outcomes in childhood?

a. Does the association of infant and child outcomes with WIC vary by age at enrollment or duration of WIC participation?
b. Does the association of infant and child outcomes with WIC vary by participant factors such as age of the mother at delivery, race/ethnicity of mother, geographic location (e.g., region, urban vs. rural), education of the mother, employment status of the mother, marital status, or housing (e.g., public, homeless)?

Analytic Framework

Figure 2 displays the analytic framework we used to address the Key Questions.

Figure 2. Analytic framework for assessing the association of WIC participation with maternal and child outcomes



KQ = Key Question; NICU = neonatal intensive care unit; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children

Study Selection

We searched PubMed, Embase®, CINAHL, ERIC, SCOPUS, PsycINFO, and the Cochrane Central Register of Controlled Trials. We conducted two literature searches: one from January 2009 through September 2020 and the other, a targeted search for selected outcomes (infant mortality, maternal mortality, and child development and academic achievement), from January 2000 through September 2020. We extended the search for studies on the latter back to 2000 because the non-dietary outcomes were thought to be less impacted by the 2009 food package change and may not have been reported in many recent studies.

We based study selection on the PICOTS framework (populations, interventions, comparators, outcomes, timing, and settings) detailed in Table 1. We provided full details on the search strategy in Appendix A and a list of the excluded studies in Appendix B. We included both quantitative and qualitative studies. We considered qualitative studies that provided insights about the association of WIC with outcomes in Table 1. We hand-searched the lists of references of relevant systematic reviews and reports. We searched the grey literature for unpublished studies relevant to this review that met the inclusion criteria. The results of the literature search are in Appendix C. As part of the grey literature search, AHRQ posted a Federal Register Notice requesting submission of relevant information using a Supplemental Evidence and Data for Systematic Review portal.[17]

Searches will be updated for new studies while the draft report is posted for public comment. Studies identified during the updated search will be assessed using the process described above. New eligible studies will be incorporated into the report prior to finalization.

Table 1. PICOTS (populations, interventions, comparisons, outcomes, timing, and setting) inclusion and exclusion criteria

PICOTS elements	KQ1 Inclusion	KQ2 Inclusion	KQ1 and KQ2 Exclusion
Population	**Women** who participated in WIC during pregnancy and their infants from birth to 28 days **Participant factors include** age of mother at delivery, race/ethnicity of mother, geographic location, education of mother, employment status of mother, marital status of mother, housing, parity, and maternal nutritional status at enrollment	**Infants/children** who participated in WIC (ages from 29 days up to 5 years) **Participant factors include** age of mother at delivery, race/ethnicity of child (or mother), geographic location, education of mother, employment status of mother, marital status of mother, housing, parity of mother, and maternal and/or child nutritional status at enrollment	Animal studies
Intervention	Participation in WIC with service provisions (food package) from 2009 onwards, defined at a minimum as enrolling in WIC for one month or more	Participation in WIC with service provisions (food package) from 2009 onwards, defined at a minimum as enrolling in WIC for one month or more	No intervention of interest
Comparison	**Women who were eligible** for WIC but did not participate during pregnancy and their infants from birth to 28 days; duration of WIC participation; exposure to pre-2009 service provisions (food package)	**Infants/children who were eligible** for WIC but did not participate at the age studied (ages from 29 days up to 5 years); duration of WIC participation; exposure to pre-2009 service provisions (food package)	Quantitative studies that do not report on the comparison group

PICOTS elements	KQ1 Inclusion	KQ2 Inclusion	KQ1 and KQ2 Exclusion
Outcomes[a]	**Maternal health outcomes [health risk] in pregnancy and postpartum**: mortality, morbidity, anemia, mode of delivery, weight status, health care utilization, health behaviors **Infant birth outcomes**: fetal death, stillbirth and neonatal mortality, gestational age, birth weight, small/large for gestational age, NICU admission, hospital length of stay **Breastfeeding** **Dietary outcomes:** Dietary practices of mothers, diet quality, household food security	**Infant and child health outcomes**: mortality, morbidity, anemia, health care utilization **Child anthropometric status or growth outcomes**: weight-for-age, length- or height-for-age, weight-for-length, or weight-for-height percentile or Z-score, BMI-for-age percentile or Z-score, underweight, obesity, growth velocity **Breastfeeding** **Dietary outcomes:** Dietary practices of infants and children, diet quality, household and child food security, food purchasing behavior at the participant or household level **Child development and academic achievement:** cognitive development, social development, motor development, communication and adaptive behavior, development risk, academic achievement	Studies that do not report any of the outcomes of interest
Timing[b]	• Studies used data 2009 onwards • Studies published since 2009 that compare results before and after 2009 food package change	• Studies used data 2009 onwards • Studies published since 2009 that compare results before and after 2009 food package change	
Setting	Any jurisdiction served by a WIC state or local agency	Any jurisdiction served by a WIC state or local agency	
Study design/type	Intervention trials (randomized and non-randomized), observational studies, quasi-experimental, e.g., before-after, interrupted time series, qualitative studies, regression discontinuity approaches	Intervention trials (randomized and non-randomized), observational studies, quasi-experimental, before-after, interrupted time series, qualitative studies	• Studies published before 2009 or no data since 2009 for all the outcomes except maternal mortality, infant mortality, child development/school performance • Publications with no original data (e.g., editorials, letters, comments, reviews) • Full text not presented or unavailable, abstracts only • WIC program materials, brochures, and training manuals • Descriptions of WIC participation levels and participant characteristics without outcome data • Descriptive research on WIC implementation, operations, and program costs • **Qualitative studies** of barriers/facilitators related to

PICOTS elements	KQ1 Inclusion	KQ2 Inclusion	KQ1 and KQ2 Exclusion
			WIC participation but not linked to outcome

BMI = body mass index; KQ = Key Question; NICU = neonatal intensive care unit; WIC=Special Supplemental Nutrition Program for Women, Infants and Children.
[a]See Appendix A for a detailed list of outcomes.
[b]Studies not using data collected after 2009 will be included for specific key outcomes (maternal mortality, infant mortality, child development and academic achievement).

Data Extraction and Risk of Bias Assessment

We formed reviewer pairs to include personnel with both topic and methodological expertise. Paired investigators abstracted data sequentially and independently assessed risk of bias for individual studies.

Reviewers extracted information on study characteristics, the WIC program (e.g., national, state, local agencies), participant characteristics, eligibility (with respect to WIC exposure for intervention and comparison), and results of each outcome. In addition, we abstracted unadjusted (or crude) event rates for WIC versus non-WIC populations (most commonly reported in a table with baseline characteristics) to provide supporting (or refuting) evidence. Owing to the very low quality of some study designs (i.e., cross-sectional, only reporting unadjusted rates), these results did not influence the final conclusions but are summarized in the text.

We also extracted results from qualitative studies that described WIC participant or staff perceptions/experiences that may have been linked to specific participant characteristics (for Key Question 1a/b and Key Question 2a/b) or an outcome of interest, with the goal of providing context for the quantitative findings. For these studies, we extracted information on a) perceptions of the 2009 food package change and its relationship with the outcomes; and b) perceptions of WIC services for subgroups of participants and explorations of how WIC might lead to differential impacts, specifically related to Key Question 1a/b and Key Question 2a/b.

We used the EPHPP (Effective Public Health Practice Project) tool to assess the risk of bias in quantitative studies addressing our outcomes of interest.[18] We selected the EPHPP tool because it was specifically developed for evaluating public health policies and programs (like WIC), has good inter-rater agreement, and addressed domains common to other risk of bias tools.[18] We created a summary assessment of "overall risk of bias" for each study by grouping the domains included in the tool. The domains included assessment of study selection bias, appropriate adjustment for confounders (including age, race, ethnicity, marital status, household size, education [mother/caregiver], spoken language, household income (Federal poverty level), sex of infant/child, co-enrollment in other programs), data collection methods, withdrawals, and drop-outs. For qualitative studies, reviewers assessed study quality using the Joanna Briggs Institute Checklist.[19] See Appendix A for details on the data extraction.

Data Synthesis and Analysis

We presented results by the Key Questions and outcomes. We conducted descriptive synthesis for each Key Question. Evidence Tables show detailed study characteristics and results, and summary tables highlight the main findings. We qualitatively summarized results from qualitative studies that described WIC participant or staff perceptions/experiences that were linked to specific participant characteristics or an outcome.

To determine whether meta-analyses were appropriate, we considered whether studies were adequately homogenous with respect to key variables (population characteristics, study design,

data source, study duration, intervention (comparison), and outcome measures). Meta-analyses were deemed not appropriate for all comparisons and outcomes owing to the small number of studies reporting for each comparison and outcome category and heterogeneity in the studies' measures of the exposure and outcomes. Studies generally did not report enough data to support calculation of standardized mean differences.

Minimal Clinically Important Difference

In evaluating WIC, a social safety net program, we considered the "important difference" at a population or policy level in addition to the difference at an individual clinical level. A difference that is very small at the clinical level can be associated with meaningful impact in a large population. When warranted, based on the evidence, we sought to identify appropriate reference points for the magnitude of effect from subject matter experts, statistical rationale (proportion of a standard deviation), evaluations of public health, safety net or prenatal care programs, and cost-benefit analyses.

Grading the Strength of the Body of Evidence

After synthesizing the evidence, we graded the strength of evidence (SOE) from the quantitative studies using the grading scheme recommended by the AHRQ Methods Guide for Conducting Comparative Effectiveness Reviews.[20] We applied evidence grades to the bodies of evidence about each comparison for each outcome. In assigning evidence grades, we considered four recommended domains, including study limitations (includes study design and ratings of risk of bias), directness of the evidence, consistency across studies, and precision of any estimates of effect. We did not formally assess the domain of reporting bias because of the lack of reliable methods for identifying reporting bias in observational studies. We assigned the final SOE grade by evaluating and qualitatively considering the assessments of the above domains and the overall assessment of the results across studies. We classified the SOE into four categories: high, moderate, low, and insufficient (Table 2).

We considered each SOE domain qualitatively across a continuum, even though the individual domains were reported categorically. Therefore, the final SOE for two outcomes could be different despite them having similar categorization of the individual domains. Although a greater number of studies contributing evidence for an outcome may lead to higher grade, the grade depends heavily on the quality of the studies.

Table 2. Definitions of the grades of overall strength of evidence

Grade	Definition
High	We are very confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has few or no deficiencies. We believe that the findings are stable (i.e., another study would not change the conclusions).
Moderate	We are moderately confident that the estimate of effect lies close to the true effect for this outcome. The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	We have limited confidence that the estimate of effect lies close to the true effect for this outcome. The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome. No evidence is available, or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Results

We begin by describing the results of the literature searches. We then provide an overall description of included studies. The remainder of the chapter is organized by Key Question and outcomes. For each outcome, the direct evidence regarding WIC participation is presented by a list of key points, summary table, and synthesis of evidence. Where applicable, the presentation includes a summary table and synthesis of the indirect evidence regarding WIC participation from studies of the 2009 food package change among WIC participants. We synthesized the quantitative and qualitative studies separately by outcomes.

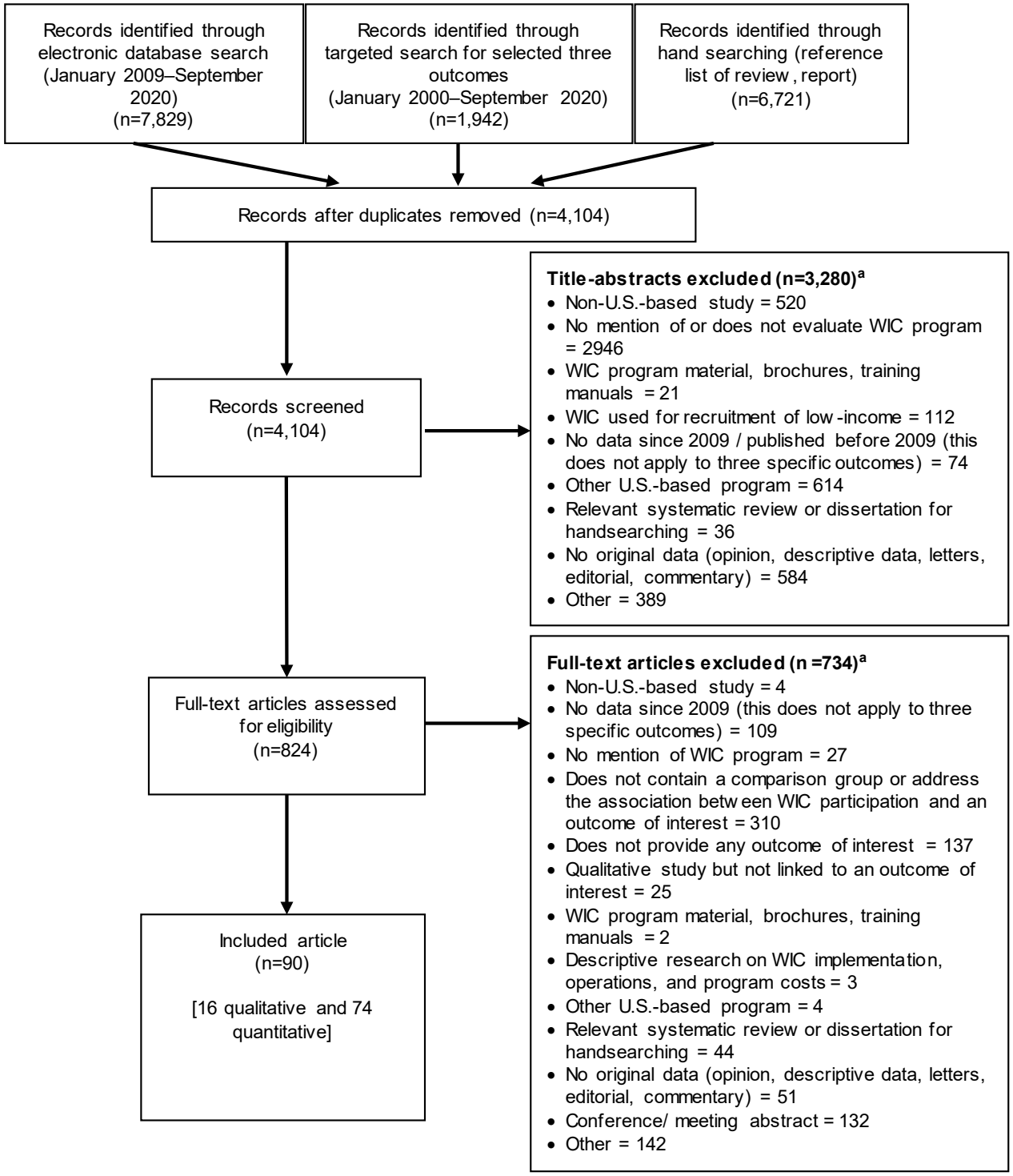
The presentation of results follows from the PICOTS table with three exceptions. First, because breastfeeding represents an outcome for both the mother and child and is associated with both maternal and child WIC participation, we present the breastfeeding results together and placed them in the Key Question 2 section. Second, studies of maternal dietary intake were not limited to women who were direct beneficiaries (receiving a food package). Therefore, the dietary outcome results of women who were direct beneficiaries are presented in Key Question 1, and studies of maternal dietary intake associated with child WIC participation are summarized in Key Question 2. Third, although in the PICOTS table we considered food purchasing and redemption outcomes for both Key Question 1 and Key Question 2, the studies of purchasing and benefit redemption outcomes focus on the household. Because households are most likely to participate in WIC because of children, we presented these findings as part of Key Question 2. Detailed evidence tables (study characteristics, eligibility criteria, and relevant outcomes) and study quality assessments are available in Appendix D.

Results of the Literature Search

The results of the published literature search are summarized in Figure 3. Combining all the database searches and hand searching yielded 4,104 unique citations. The title and abstract screening excluded 3,280 citations, and the article screening excluded 734 citations (Appendix B). Ninety published studies met our inclusion criteria.

Manual searching of the grey literature identified three reports on the association of WIC participation and child outcomes.[21-23] Thus, a total of 93 studies were included. The Federal Register notice requesting Supplemental Evidence did not yield any other studies.

Figure 3. Summary of the results of the published literature search



WIC = Supplemental Nutrition Program for Women, Infants, and Children
[a]Total exceeds the number of citations in the exclusion box, because citations could be excluded for more than one reason (i.e., reviewers did not need to agree on reason for exclusion.)

Description of Included Studies

Of the included studies, 16 were qualitative studies, 74 were quantitative studies, and 3 were reports with quantitative or qualitative data from the grey literature. Despite the large number of studies and the fact that studies may report on more than one outcome, the number of quantitative studies per outcome is often small, and the qualitative studies largely focused on breastfeeding, dietary outcomes, and food purchasing outcomes (Table 3). The quantitative studies were also classified as to whether they provided direct or indirect evidence regarding WIC participation and the outcome. Figures 4 through 6 characterize quantitative studies by data collection period, type of evidence, and outcome. As shown, the data collection period for the included studies ended prior to the COVID-19 pandemic.

Table 3. List of included studies by Key Question*

	Quantitative Studies		Qualitative Studies
Key Question (KQ)	Direct evidence[a]	Indirect evidence[b]	
KQ1 (including 1a and 1b)-Maternal and infant birth outcomes	12	2	3
KQ2 (including 2a and 2b) -Infant and child dietary and health outcomes	29	26	5
KQ1 & KQ2 Maternal and infant breastfeeding outcomes	7	7	9

*A study could address multiple outcomes, so the numbers shown do not add up to the total number of studies

[a]**Direct evidence** regarding WIC participation and the outcomes involves a comparison of outcomes for WIC participants versus WIC-eligible non-participants.

[b]**Indirect evidence** refers to studies of outcomes among WIC participants only, including studies of the 2009 food package change.

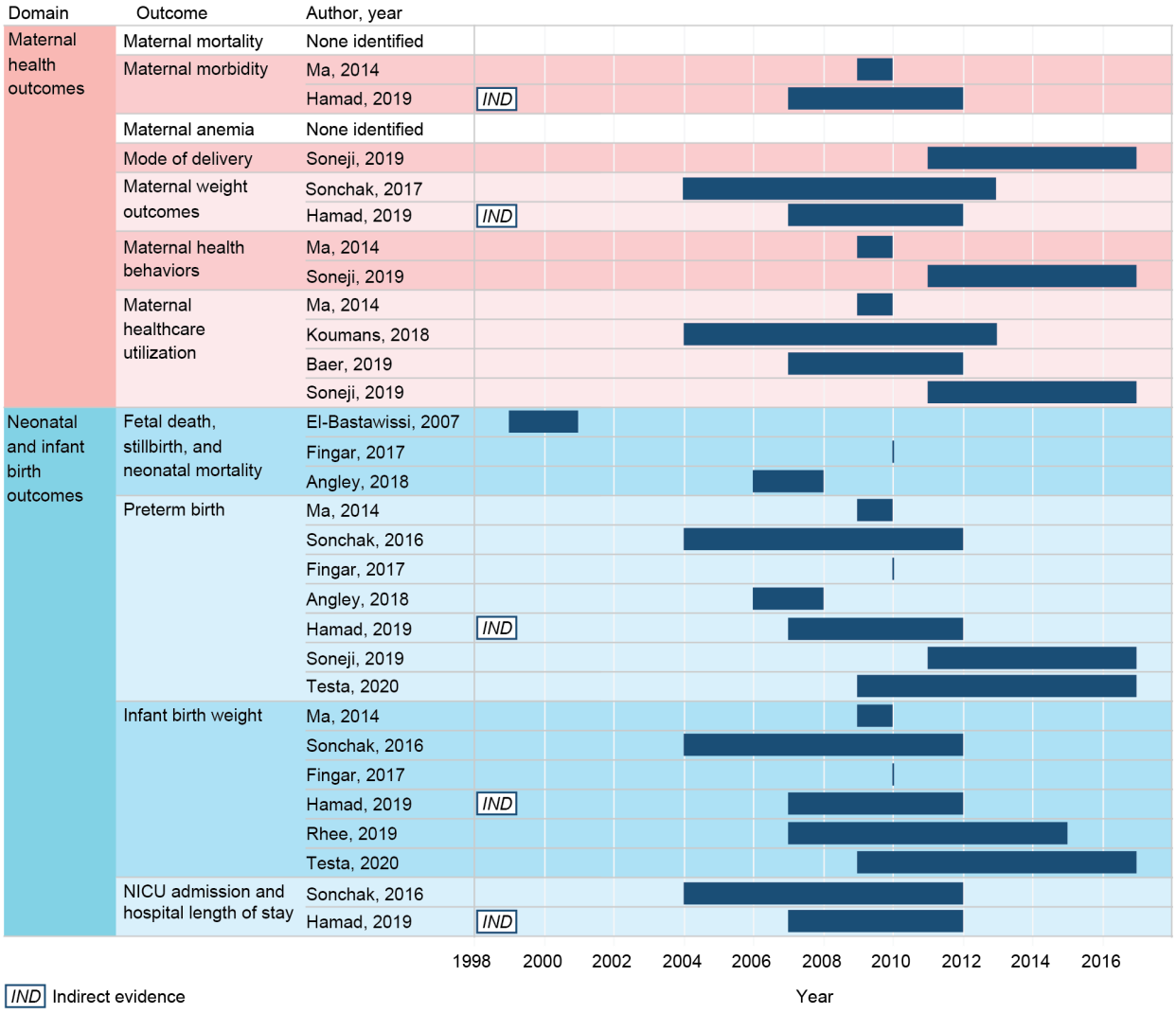
Included quantitative studies were observational: no RCTs assessed the association between WIC participation and maternal/child outcomes. The overall risk of bias was high for 45 quantitative studies and moderate for 32 quantitative studies. The primary sources of bias in the studies were selection bias and inadequate adjustment for confounding, including that owing to secular trends. The characteristics of the studies, participants, and interventions (WIC programs) are listed in Appendix D, Evidence Tables D-1 through D-29.

Most studies did not report details of the degree of WIC participation (e.g., duration, intensity). The most common description of WIC participation was self-reported on a questionnaire, without specification of duration or receipt of benefits. The comparison group of eligible non-participants was most often identified by participation in Medicaid or SNAP or, less frequently, by identification of households with incomes less than 185 percent of the Federal Poverty Guidelines. Studies were excluded from the main analysis if the non-participant comparison was not WIC-eligible, or the studies did not provide evidence of substantial adjustment for socio-economic status (e.g., percent of the Federal Poverty Guidelines). For studies that included time periods before and after the 2009 food package change and included both WIC participants and eligible non-participants, we reported findings on the WIC versus non-WIC comparison.

Few studies were identified that addressed Key Question 1a/b or Key Question 2a/b. The included studies of duration are in Key Question 2 and focus on child diet and anthropometric outcomes. Included studies for Key Question 1b or Key Question 2b, regarding whether associations of WIC participation with the outcome varied by participant characteristics, most often focused on maternal race or race/ethnicity. Maternal race was reported differently across studies (e.g., Black or African-American), and many studies characterized mothers in terms of

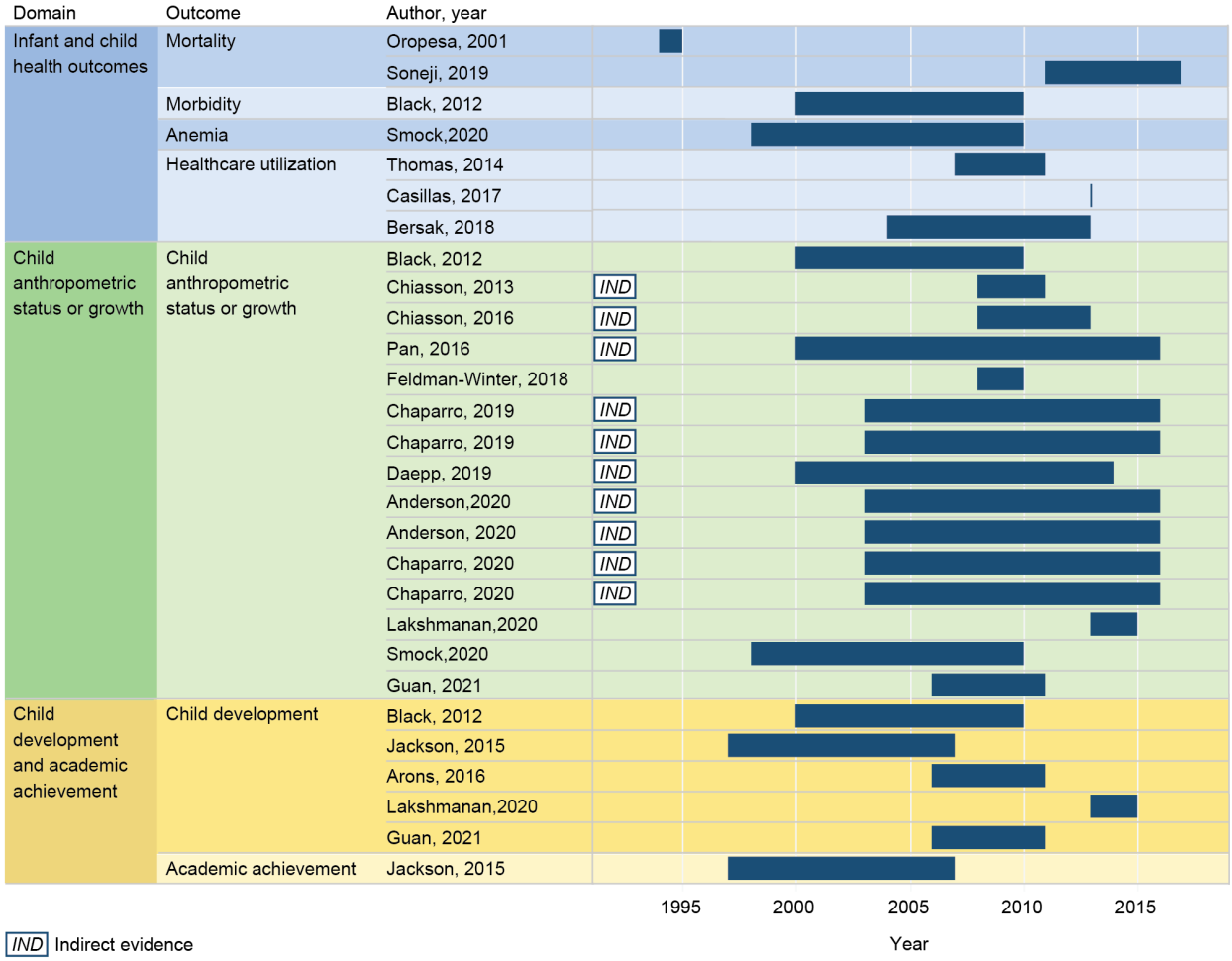
combined race and ethnicity categories (e.g., Black, White, or Hispanic as opposed to non-Hispanic Black, non-Hispanic White, or Hispanic). We maintained the reporting of the referenced paper.

Figure 4. Data collection periods of included quantitative studies on specific maternal health and infant birth, or neonatal outcomes (Key Question 1)



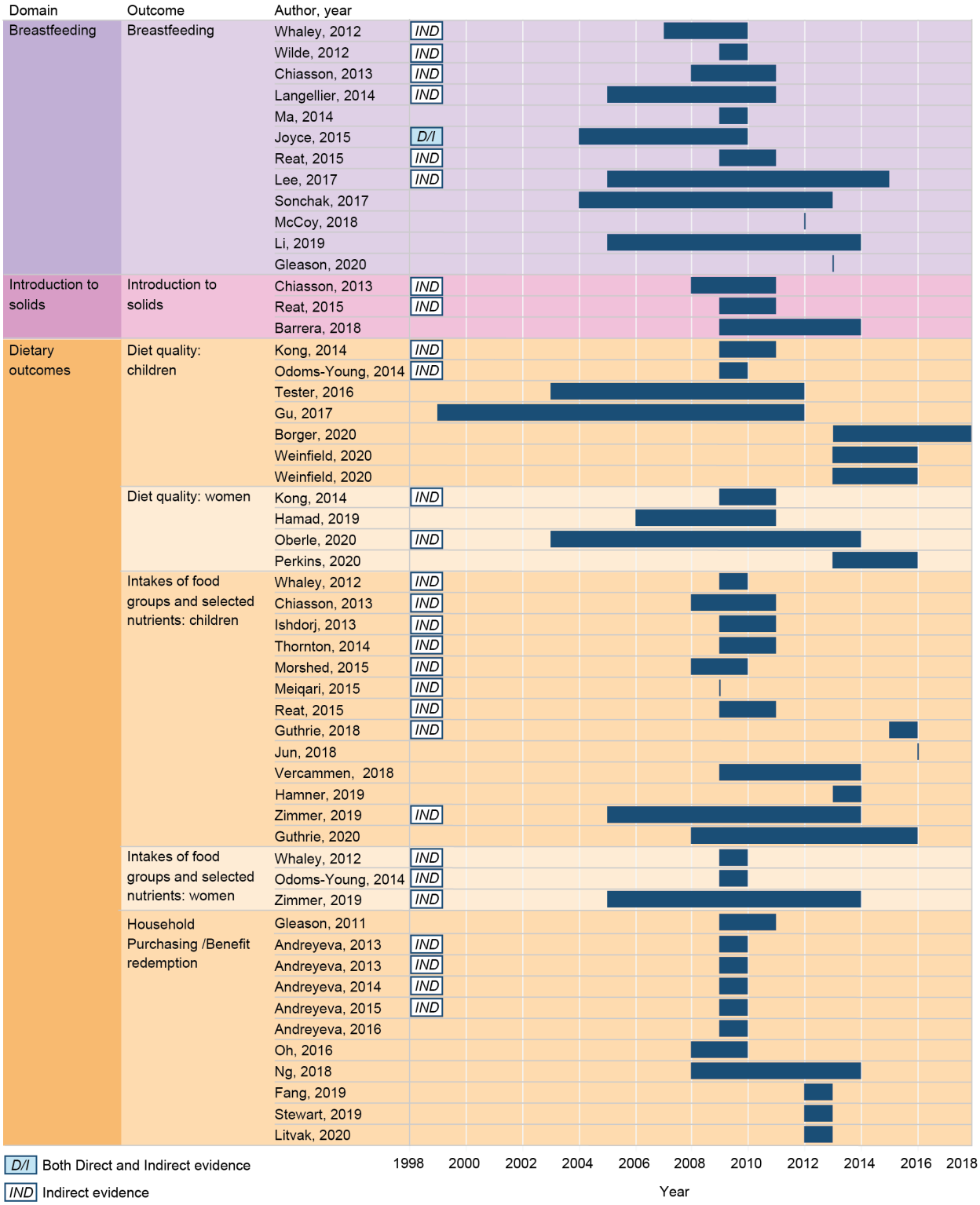
Indirect evidence refers to studies of outcomes among WIC participants only, including studies of the 2009 food package change

Figure 5. Data collection periods of included quantitative studies on infant/child health, growth, and development outcomes (Key Question 2)



Indirect evidence refers to studies of outcomes among WIC participants only, including studies of the 2009 food package change

Figure 6. Data collection periods of included quantitative studies on breastfeeding and diet outcomes for Key Questions 1 and 2



Indirect evidence refers to studies of outcomes among WIC participants only, including studies of the 2009 food package change

Key Question 1. Among women who are eligible to participate in WIC, how is WIC participation during pregnancy associated with maternal and infant birth outcomes?

Key Points

Maternal Health Outcomes

- The evidence was insufficient to determine whether maternal WIC participation was associated with the outcomes of gestational diabetes, preeclampsia, or gestational hypertension (SOE: Insufficient).
- No eligible studies reported on the outcomes of maternal mortality, gestational hypertension, anemia in pregnancy, mode of delivery, pre-pregnancy weight status or BMI, or postpartum weight retention (SOE: Insufficient).

Neonatal and Infant Birth Outcomes

- The evidence was insufficient to determine whether maternal WIC participation was associated with decreased risk of stillbirth or neonatal death (SOE: Insufficient).
- Maternal WIC participation during pregnancy may be associated with lower risk of preterm birth (SOE: Low).
- Maternal WIC participation during pregnancy may be associated with lower risk of low birth weight in infants (SOE: Low).
- The evidence was insufficient to determine whether maternal WIC participation was associated with decreased NICU stays (SOE: Insufficient).

Maternal Dietary Outcomes

- The evidence was insufficient to determine whether maternal WIC participation during pregnancy was associated with better diet quality, food group, or nutrient intakes (SOE: Insufficient).

Maternal Health Outcomes

Two studies reported on the association between WIC participation and maternal health outcomes. One single-state (South Carolina) cohort used birth certificate data to assess the outcome of gestational weight gain for WIC participation (vs. non-WIC participation) among Medicaid enrollees.[24] One large pre-post study used a difference in differences analysis to compare outcomes before and after the 2009 food package change for WIC recipients (vs. general population of non-WIC recipients)[25] and reported three maternal outcomes.

Because of the paucity of studies reporting maternal health outcomes, we also reported unadjusted rates of outcomes (most commonly abstracted from tables of baseline characteristics) in four additional studies to provide supporting or refuting evidence. These results are not included in the summary tables and did not influence the SOE or final conclusions because of the very low quality of study design (i.e., cross-sectional, unadjusted rates), but they are summarized in the text. Table 4 presents the summary of findings and SOE from one study that most directly

addressed the question regarding WIC participation and maternal health outcomes. See Appendix D, Evidence Tables D-30 through D-41 for additional details.

Table 4. Summary of evidence on whether maternal health outcomes were associated with WIC participation compared with eligible non-WIC participants

	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Maternal mortality	0 studies	NA	Inconclusive	Insufficient
Maternal morbidity				
Gestational hypertension	0 studies	NA	Inconclusive	Insufficient
Anemia in pregnancy	0 studies	NA	Inconclusive	Insufficient
Preeclampsia	0 studies	NA	Inconclusive	Insufficient
Gestational diabetes	0 studies	NA	Inconclusive	Insufficient
Maternal pregnancy outcomes				
Mode of delivery	0 studies	NA	Inconclusive	Insufficient
Gestational weight gain	1 cohort study among South Carolina births (275,482 mothers) 2004-13[24]	• Using maternal fixed effects, WIC participation associated with a decreased likelihood of less than recommended weight gain (3%).	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Precise
Pre-pregnancy weight status or BMI	0 studies	NA	Inconclusive	Insufficient
Postpartum weight retention	0 studies	NA	Inconclusive	Insufficient
Maternal health behaviors				
Smoking	0 studies	NA	Inconclusive	Insufficient
Alcohol use	0 studies	NA	Inconclusive	Insufficient
Maternal health care utilization				
HIV testing	0 studies	NA	Inconclusive	Insufficient
Receipt of early prenatal care	0 studies	NA	Inconclusive	Insufficient

BMI = body mass index; HIV = human immunodeficiency virus; NA = not applicable; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Insufficient strength of evidence indicates that evidence is unavailable or does not permit a conclusion.

Maternal Mortality

No eligible studies reported on the outcome of maternal mortality.

Maternal Morbidity (Preeclampsia, Gestational Diabetes, Gestational Hypertension, Anemia)

No studies reported on the adjusted association between WIC participation and maternal morbidity including preeclampsia, gestational diabetes, gestational hypertension, or anemia in pregnancy. Two studies reported unadjusted rates of maternal outcomes.[26, 27] One was a national cohort study using birth certificate data (N=11,148,261) and showed slightly greater unadjusted rates of **gestational diabetes** between women with and without WIC in pregnancy among Medicaid-insured expectant mothers (5.6% vs. 5.0%, $p<0.001$).[26] That study also reported

slightly lower unadjusted rates of **gestational hypertension** with (vs. without) WIC in pregnancy (5.2% vs. 5.3%, p=0.03). The second study reported similar unadjusted rates of **gestational diabetes and gestational hypertension** among 1,796 mothers with WIC participation (vs. income-eligible non-WIC participants).[27]

The two studies that reported unadjusted rates had high study limitations, and thus did not influence the SOE. We graded the SOE as insufficient for drawing any conclusion related to the association between gestational hypertension and WIC participation because no studies reported adjusted analyses. See Appendix D, Evidence Tables D-30 through D-32 for details.

Maternal Pregnancy Outcomes

Mode of Delivery

No studies reported on the adjusted association between mode of delivery and WIC participation. One national cohort study using birth certificate data (N=11,148,261) compared the unadjusted rates of mode of delivery between Medicaid-insured mothers with and without WIC benefits during pregnancy. That study showed that women with WIC had lower unadjusted rates of **spontaneous vaginal delivery** (64.9% vs. 66.6%), but higher rates of **cesarean delivery** (32.1% vs. 30.5%).[26]

We graded the SOE as insufficient for drawing any conclusion related to the association between mode of delivery and WIC participation because no studies reported adjusted analyses to assess this association. See Appendix D, Evidence Table D-35 for details of the outcome data.

Pre-pregnancy and Postpartum Weight Status

No studies assessed the association of WIC participation with weight status in women before and after pregnancy (e.g., pre-pregnancy body mass index (BMI) or post-partum weight loss).

Gestational Weight Gain

One study reported on the outcome of gestational weight gain.[24] Studies assessed weight gain as "less than recommended," "greater than recommended," and "within recommended" according to the Institute of Medicine (IOM) 2009 recommendations for weight gain for each category of pre-pregnancy BMI. Neither study adjusted for duration of pregnancy.

One single-state (South Carolina) cohort using birth certificate data (N=275,482 women) showed that WIC participation (vs. non-WIC participation) among Medicaid enrollees was associated with a decreased likelihood of "less than recommended" weight gain (3.3% lower adjusted mean risk; standard error (SE) 0.45%).[24]

Overall, the evidence is insufficient to determine whether WIC participation is associated with gestational weight gain, based on concerns regarding the comparison group and high limitations of the single-state cohort study.[24] See Appendix D, Evidence Table D-37 for details.

Maternal Health Behaviors

No studies reported on the adjusted association between maternal health behaviors and WIC participation. Two studies reported on the unadjusted association between WIC participation and maternal health behaviors of **smoking and alcohol use in pregnancy and before conception**.[26, 27] We did not find studies that reported on other maternal health behaviors (e.g., exercise).

Regarding smoking, one cohort study using birth certificate data (N=11,148,261 mothers; 2011–2017) showed similar unadjusted rates of smoking in the three months before pregnancy

(13% vs. 13.8%) and in smoking during pregnancy (13% vs. 13.7%) between women with Medicaid who received WIC benefits versus those who did not receive WIC benefits in pregnancy.[26] In a second study using South Carolina data, smoking rates in the last three months of pregnancy were lower in 1,024 women who received WIC in pregnancy compared with 214 income-eligible women who did not receive WIC in pregnancy (12.9% vs. 20.6%), which was statistically significant. This study also reported no between-group difference in the rate of maternal alcohol use in the last three months of pregnancy.[27]

We graded the SOE as insufficient for drawing any conclusion related to the association between smoking and alcohol use in pregnancy and WIC participation because there were only two studies and neither reported adjusted analyses (two reported on smoking and one reported on alcohol use) and they had high limitations owing to risks of confounding. See Appendix D, Evidence Tables D-38 and D-39 for details of the outcome data.

Maternal Health Care Utilization

No studies reported on the adjusted association between maternal health care utilization and WIC participation. Four studies reported on unadjusted rates of maternal health care utilization prenatally or at delivery.[26-29] No studies assessed postpartum obstetric care utilization or any emergency room or primary care utilization. Of the utilization outcomes assessed, three studies described receipt of early prenatal care in women who received WIC versus WIC-eligible non-participants, but there was no statistical testing of differences between the two groups.[26, 27, 29]

We also identified one study that used PRAMS (Pregnancy Risk Assessment Monitoring System) data from 36 states and New York City and showed that women who received Medicaid and WIC had greater unadjusted rates of human immunodeficiency virus (HIV) testing (83.8%) compared with women with Medicaid only (78.4%), WIC only (79.2%), or neither Medicaid nor WIC (66.9%).[28]

We graded the SOE as insufficient for drawing any conclusion related to the association between maternal health care utilization and WIC participation because of the paucity of studies reporting adjusted associations between WIC and maternal health care utilization. Also, the four studies had high limitations owing to risk of confounding from lack of adjusted analyses. See Appendix D, Evidence Tables D-40 and D-41 for details.

Maternal Health Outcomes in 2009 Food Package Change Studies

Studies that compared outcomes among WIC participants before versus after the 2009 food package change provided indirect evidence regarding the Key Question about the association of outcomes with WIC participation.

One large study compared maternal antepartum and intrapartum outcomes for WIC participants before and after the 2009 food package change as they relate to changes over time among both eligible and non-eligible non-WIC participants in the general population.[25] This study used a pre-post study design and difference in differences analysis with maternal fixed effects after linking birth certificate and hospital discharge data from 2007–2012 (2,897,537 infants born to 2,441,658 mothers). The authors found that the revised food package was associated with small reductions in the incidence of maternal **preeclampsia** (-0.6% points; 95% confidence interval (CI), -0.8 to -0.4) for WIC participants compared with the general population. Because of the severity of preeclampsia, a small reduction in incidence is clinically

significant when translated to the population level.[25] In this same study, the revised food package was not associated with a difference in the incidence of **gestational diabetes** (-0.04% points; 95% CI, -0.3 to 0.2). See Appendix D, Evidence Tables D-33 and D-34 for details.

The same study showed a reduction in the percentage of pregnancies with "greater than recommended" weight gain (-3.2%; 95% CI, -3.6 to -2.7). The study also reported an increase in the adjusted percentage of women with recommended **gestational weight gain** (2.3%; 95% CI, 1.8 to 2.8) and only a small increase in those with "less than recommended" gestational weight gain (0.9%; 95% CI, 0.5 to 1.2).[25] Analyses were adjusted for sociodemographic variables on the birth certificate, education, age, race/ethnicity, parity, and infant's sex and year of birth. See Appendix D, Evidence Tables D-36 for details.

The evidence was insufficient to determine whether the revised food package was associated with differences in preeclampsia, gestational diabetes, gestational hypertension, or gestational weight gain among WIC participants compared with non-WIC participants. The SOE was insufficient because there was only a single study with medium limitations, and the study did not directly compare WIC participants with eligible non-participants.

Neonatal and Infant Birth Outcomes

Four studies assessed the association of maternal WIC participation with neonatal and infant birth outcomes. Three of the studies had comparison groups of individuals who were income eligible (based on Medicaid insurance) for WIC but did not participate.[26, 30, 31] One of the studies was a large pre-post study using a difference in differences analysis to compare outcomes before and after the 2009 food package change for WIC recipients (vs. general population non-WIC recipients).[25]

Because of the paucity of studies reporting infant health outcomes, we also reported unadjusted rates of outcomes (most commonly abstracted from tables of baseline characteristics) to provide supporting or refuting evidence. These results are not included in the summary tables and did not influence the SOE or final conclusions because of the very low quality of study design (i.e., cross-sectional, unadjusted rates), but they are summarized in the text.

Table 5 summarizes findings and SOE from the three studies that most directly addressed the question regarding WIC participation and neonatal and infant birth outcomes. The studies were too heterogeneous (in terms of study design, study population, and outcome measures) to support a meta-analysis. See Appendix D, Evidence Tables D-144 and D-158 for details.

Table 5. Summary of evidence on whether neonatal and infant birth outcomes were associated with maternal WIC participation compared with eligible non-WIC participants

Outcome	Number of Studies Participants (N)	Study Results	Conclusions	Strength of evidence (Rationale)[a]
Fetal death, stillbirth and neonatal mortality	• 1 state-level retrospective cohort (236,564 women)[30]	• No statistically significant association between WIC participation and perinatal death, after adjusting for time-varying exposure to WIC.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Imprecise

Outcome	Number of Studies Participants (N)	Study Results	Conclusions	Strength of evidence (Rationale)[a]
Preterm birth	**3 studies** • 1 state-level cross-sectional study (102,079 mothers)[31] • 1 national cohort study (11,148,261 infants)[26] • 1 state-level retrospective cohort (236,564 births)[30]	• WIC associated with 3% longer gestation in adjusted fixed effects model. • Among 2 other cohort studies, WIC associated with 12% - 15% lower risk of preterm birth.	Maternal WIC participation may be associated with decreased risk of preterm birth and longer gestation.	Low • Study limitations: Medium • Directness: Direct • Consistency: Inconsistent • Precision: Precise
Infant low birth weight	**3 studies** • 1 state-level retrospective cohort (236,564 infants)[30] • 2 state-level cross-sectional studies (336 mothers[32] and 102,079 mothers[31])	• WIC participation was associated with significantly decreased risk of low birth weight infant in two studies, but not in one study .	Maternal WIC participation may be associated with decreased risk of low birth weight.	Low • Study limitations: Medium • Directness: Direct • Consistency: Consistent • Precision: Precise
NICU admission and hospital length of stay	• 1 state-level cross-sectional study (102,079 mothers)[31]	• WIC participation was associated with a decline (-1.6%) in the probability of NICU admission among women with Medicaid	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Imprecise

NICU = neonatal intensive care unit; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Low strength indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result, and insufficient evidence indicates that evidence is unavailable or does not permit a conclusion.

Fetal Death, Stillbirth and Neonatal Mortality

Two studies reported on the association (one with adjusted estimate of association) between WIC participation and fetal death/stillbirth or neonatal death (within 28 days after delivery).[30, 33]

One large retrospective cohort study used 2010 census data linked to California birth, hospital discharge, and WIC participation data (N=236,564) and evaluated the association of WIC redemption (vs. non-redemption) among women who were eligible based on Medicaid records. The study assessed the association of the timing of WIC enrollment and WIC food package utilization with perinatal death, defined as fetal or neonatal death 20 through 46 weeks after the last menstrual period. After adjustment for maternal sociodemographic and health characteristics and allowing for WIC exposure to vary over time, they reported a non-significantly lower hazard ratio (HR) for **infant perinatal death** for infants born to women who enrolled in WIC (0.89; 95% CI, 0.78 to 1.02) compared with women who were not enrolled in WIC during pregnancy.[30]

The other study assessed the association between WIC participation and fetal death, stillbirth, or neonatal mortality.[33] A single-state retrospective cohort study (N=39,608 births; 1991–2001) reported a lower unadjusted crude rate of **fetal death** in women enrolled in WIC (vs. income-eligible women not enrolled in WIC) (0.3% vs. 1.0%, p<.001).[33] See Appendix D, Evidence Table D-144 and D-145 for details of the outcome data.

Overall, the SOE was insufficient to support a conclusion for the association between maternal WIC participation and the risk of stillbirth and perinatal death. We graded the SOE as insufficient based on high study limitations owing to risk of confounding (e.g., only one study reported adjusted rates), imprecise findings, and lack of consistency across studies.

Preterm Birth

Four studies reported on WIC participation and preterm birth.[26, 27, 30, 31]

A national cohort study used birth certificate data (N=11,148,261 births) from Medicaid insured mothers who received (vs. did not receive) WIC benefits in pregnancy. That study showed a lower adjusted odds ratio (OR) for preterm birth (0.88; 95% CI, 0.86 to 0.87) associated with WIC participation after adjustment for sociodemographic characteristics, clinical risk factors, receipt of prenatal care, and maternal smoking.[26]

Three other observational studies (2 with adjusted analyses) showed a decrease in preterm birth associated with WIC participation.[27, 30, 31] In one large single-state retrospective cohort that linked census, birth certificate, hospital discharge, and WIC participation data (N=236,564 women), WIC was associated with a lower risk of **preterm birth** (HR 0.85; 95% CI not reported) after adjustment for maternal characteristics and allowing for WIC exposure to vary over time.[30] Another single-state cross-sectional study used vital statistics natality data (N=102,079 mothers; 2004-2012) and showed that WIC was associated with a 2.71 percent ($p<0.01$) higher probability of longer gestation in an adjusted fixed effects model.[31] One study using South Carolina PRAMS data (N=1,796 women; 2009-2010) among WIC (vs. non-WIC) participants showed no statistically significant difference in the rate of **preterm births** between the two groups (10.6% vs. 12.4%).[27] See Appendix D, Evidence Table D-146, D-148, and D-150 through D-151 for details.

We concluded that WIC participation may be associated with a lower risk of preterm birth. We graded the SOE as low based on medium study limitations, inconsistency across four studies, and relatively precise findings.

Infant Birth Weight

Three studies reported on the association between WIC participation and infants with **low birth weight**.[27, 30, 31] One large single-state retrospective cohort study linked 2010 census, birth, hospital discharge data, and WIC participation data (N=236,564 women). Among women who were income-eligible based on Medicaid records, WIC redemption (vs. non-redemption) was not significantly associated with a decreased risk of low birth weight (HR 0.89; 95% CI, 0.78-1.02).[30] One cross-sectional single-state study using vital statistics natality data (N=102,079 mothers; 2004-2012) showed that, among women with Medicaid, WIC participation (vs. non-WIC participation) was associated with an absolute 2.5% ($p<0.01$) decrease in the probability of infants with low birth weight after multiple adjustments (a 24% reduction in risk).[31] In a PRAMS analysis (2009–2010), WIC was associated with a significantly lower percentage of infants with low birth weight compared with income-eligible non-WIC participants (9.7% vs. 10.5%, $p<0.025$).[27]

Overall, we concluded that WIC participation may be associated with lower risk of low birth weight in infants. We graded the SOE as low based on medium to high study limitations, relatively consistent findings across the three studies, and relatively precise findings.

We also identified a cross-sectional analysis of infants from the Children's Health Watch Cohort from Boston, Massachusetts (N=336; 2007–2015).[32] This study assessed the association between maternal homelessness, WIC participation, air pollution, and birth weight.[32] The study found that WIC participation (vs. non-WIC participation) was not significantly associated with **infant birthweight** (36g; 95% CI, -7.3g to 79.4g). See Appendix D, Evidence Tables D-153 and D-155 for details.

NICU Admission and Hospital Length of Stay

One study reported on the adjusted association between WIC participation and either NICU admission or hospital length of stay.[31] The cross-sectional single-state study among women with Medicaid (N=102,079 mothers; 2004–2012), showed that WIC was associated with a 1.6% ($p < 0.01$) adjusted decline in the probability of **NICU admission.**[31] See Appendix D, Evidence Tables D-158 for details The SOE was insufficient to support a conclusion about whether WIC participation was associated with NICU admission or hospital length of stay because of the paucity of studies and high study limitations owing to risk of confounding.

Neonatal and Infant Birth Outcomes in 2009 Food Package Change Studies

Studies that compared outcomes for WIC participants before versus after the 2009 food package change provided indirect evidence regarding the Key Question about the association of outcomes with WIC participation.

One large pre-post study using differences in differences analysis of linked birth certificate and hospital discharge data in California (N=2,897,537 infants; 2007–2012) showed that the revised food package was associated with a slightly longer mean gestational age at birth (mean of 0.018 weeks (~3 hours); 95% CI, 0.001 to 0.034) for WIC participants as compared with the general population of non-WIC participants. There was no significant association of the 2009 food package with **preterm birth** (0.17% change; 95% CI, -0.075 to 0.42).[25] Because the parallel trends assumption (that in the absence of the intervention the difference between the intervention and control group outcome was constant over time) was not met for preterm birth and because the clinical significance of 3 hours longer gestation was not clear, we interpreted these findings cautiously. See Appendix D, Evidence Table D-147 and D-149 for details.

This study also showed that the revised food package was associated with a very small reduction in the proportion of infants with **low birth weight** (-0.2%; 95% CI, -0.4 to -0.004), but not the proportion of infants with **very low birth weight** (-0.08%; 95% CI, -0.16 to 0.005) for WIC participants as compared with the general population of non-WIC participants. The revised food package was also associated with higher likelihood of being born at a birth weight **appropriate for gestational age** (0.94% points; 95% CI, 0.55 to 1.3) and lower likelihood of being born **small** (-0.42% points; 95% CI, -0.69 to -0.15) or **large for gestational age** (-0.52% points; 95% CI, -0.81 to -0.23).[25] See Appendix D, Evidence Table D-152, D-154, and D-156 for details.

This study reported no differences in **maternal hospital length of stay at delivery**, defined as more than two days for vaginal delivery or four days for cesarean delivery (-0.001% change; 95% CI, -0.31 to 0.31) or hospital readmission within one year after birth (-0.056% change; 95% CI, -0.39 to 0.27). See Appendix D, Evidence Table D-157 for details of the outcome data.

The evidence was insufficient to determine whether the 2009 food package change was associated with differences in preterm birth, infant birth weight, NICU admission, or maternal hospital length of stay among WIC participants compared with non-WIC participants. The SOE was insufficient because there was only a single study with medium limitations, and the study did not directly compare WIC participants with eligible non-WIC participants.

Breastfeeding Outcomes

Breastfeeding outcomes are combined for Key Question 1 and Key Question 2 and reported under Key Question 2.

Maternal Dietary Outcomes

A key measure used to assess dietary outcomes is the Healthy Eating Index (HEI),[34, 35] a measure of diet quality that assesses how well the diet aligns with the key recommendations of the DGA. A total HEI score (out of 100 possible points) is the sum of component scores for intake of food groups and nutrients important for good health (e.g., whole grains, fruits, vegetables, and proteins) and reverse-scored for food groups and nutrients to be consumed in moderation (e.g., sodium, added sugars, and saturated fats). In addition to the HEI total and component scores, diet quality was also assessed by calculating nutrient density of fats, carbohydrates, and proteins in the diet.

Two studies were included.[36, 37] One study compared outcomes for WIC participants with eligible non-WIC participants and provides direct evidence regarding WIC participation and the outcome (Table 6).[36] The other study examined dietary outcomes before and after the 2009 food package change for WIC participants and provides indirect evidence with respect to the association of the outcome with WIC participation.[37]

The studies were too heterogeneous (in terms of study design, study population, and outcome measures) to support a meta-analysis. See Appendix D, Evidence Tables D-42, D-44, D-46, D-47, D-48, D-49, D-55, D-57, D-59, D-60, D-62, D-65, D-67, D-69, D-71, D-73, D-75, D-81, D-83, D-88, D-90, D-94, D-96, D-98, D-100, D-105, D-107, D-109, D-111, D-113, D-115, D-117, and D-118 for details.

Table 6. Summary of evidence on maternal dietary outcomes and WIC participation during pregnancy and postpartum time periods compared with eligible non-WIC participants

Outcome	Number of Studies and Participants (N)	Study Results	Conclusions	Strength of Evidence (Rationale)[a]
Overall diet quality of pregnant/ postpartum WIC participants using the HEI-2010	1 difference in differences analysis of data from cohort study of women in Tennessee (1279 pregnant, 1177 postpartum) [36]	• WIC associated with increase of 2.4 points in HEI score during pregnancy, no difference at one month postpartum.[36]	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise
Food group and nutrient intakes of pregnant/ postpartum WIC participants	1 difference in differences analysis of data from cohort study of women in Tennessee (1279 pregnant, 1177 postpartum) [36]	• WIC associated with increase in the total fruit HEI component score during pregnancy, no difference at one month postpartum.[36]	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise

HEI = Healthy Eating Index, N = number of participants, WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

[a]Insufficient strength indicates that evidence is unavailable or does not permit a conclusion.

Maternal Dietary Outcomes During Pregnancy and Postpartum

One study examined diet quality in a cohort of 1,454 women recruited during pregnancy in Tennessee between 2006 and 2011.[36] In adjusted analyses, WIC participants consuming the revised food package had a 2.38 points higher total HEI-2010 score (95% CI, 0.09 to 4.6) during pregnancy as compared with income-eligible non-WIC participants. They also reported greater consumption of fruit (HEI-total fruit score: β, 0.39 points; 95% CI, 0.11 to 0.67), and greater but non-significant consumption of whole grains (β, 0.51 points; 95% CI, -0.05 to 1.06), and lower fat intakes (β, -1.2 g/1000 kcal; 95% CI, -2.48 to 0.07). At one-month postpartum, no significant differences in HEI-2010 scores were identified. Differences in consumption of whole grains (β, 0.31; 95% CI, -0.27 to 0.88) and fat intake (β, -1.15; 95% CI, -2.68 to 0.38) were of similar magnitude to those reported during pregnancy but were not significantly different. See Appendix D, Evidence Table D-42, D-81, D-88, D-91, D-94, D-98, D-105, D-109, D-113 for details.

Based on the paucity of studies, and medium limitations for this study, we rated the SOE as insufficient to draw conclusions regarding WIC participation and diet quality or food group or nutrient intakes.

Maternal Dietary Outcomes in 2009 Food Package Change Studies

Studies that compare outcomes for WIC participants before versus after the 2009 food package change provide indirect evidence regarding the Key Question about the association of outcomes with WIC participation.

One study conducted a cross-sectional analysis of National Health and Nutrition Examination Survey (NHANES) data to compare diet quality outcomes in WIC recipients before and after the 2009 food package change, comparing data from 2011 to 2014 with that from 2003 to 2006.[37] All women in the sample (N=312 unweighted; N=1,662,831 weighted) reported being direct beneficiaries of WIC (pregnant, breastfeeding for up to 12 months, or postpartum up to 6 months). The 2009 food package change was associated with a non-significant but higher total HEI score (β, 3.1 points; 95% CI, -1.0 to 7.2). Small but not statistically significant increased scores were detected for whole grain consumption (β, 0.9; 95% CI, -0.01 to 1.9); seafood and plant protein consumption (β, 0.7; 95% CI, -0.1 to 1.5); and consumption of empty calories, which is reverse scored, indicating decreased consumption of empty calories (β, 1.9; 95% CI, −0.2 to 4.0). See Appendix D, Evidence Table D-44, D-67, D-71, D-75, D-83, D-88, D-90, D-96, D-100, D-107, D-111, D-115 for details.

The evidence was insufficient to determine whether the revised food package was associated with differences in diet quality, food groups, and nutrient intake among WIC participants. The SOE was insufficient based on having only one study with medium limitations, precise estimates, and indirect relation to the Key Question about association with WIC participation.

Findings from Qualitative Studies About Maternal Outcomes

Three studies used qualitative methods to explore perceptions about **diet quality** and **gestational weight gain** during pregnancy. See Appendix D, Evidence Table 95 for details.

One study used focus group discussions[38] with overweight and obese pregnant and postpartum women (N=29) recruited from a community-based perinatal center in Madison, Wisconsin to explore multilevel barriers and facilitators to **healthy eating** and **gestational weight gain**. Women in the study reported that healthcare providers such as nurses, dietitians,

social workers, and WIC staff were important sources of trusted nutrition information. However, many women mentioned that they received different information from their obstetricians versus the WIC staff, and one stated that "sometimes they [WIC staff] have their views on things that are much different than your doctor's views."

Differences in the information received was also mentioned in another study conducted among WIC participants (N=59) in Los Angeles, California.[39] In this study, focus group discussions were used to examine perceptions and barriers to healthy eating and appropriate **gestational weight gain** to inform the development of an intervention. Women felt that they had limited knowledge surrounding an appropriate weight gain goal or behaviors and, while having regular weight monitoring check-ups, received little or inconsistent information from healthcare providers, including from WIC. However, a few women indicated that they learned about appropriate weight gain from WIC with one stating that "here in WIC, yes, every time they weigh me they say that 10–15 pounds is what is normal to gain during pregnancy for me. But in the [health] clinic, no." Participants in this study were also concerned about gaining too much weight during pregnancy and reported that pressure from family members to "eat for two" was a barrier to appropriate diet and weight gain.

In two studies, respondents commented on WIC as a source of advice for **healthy eating**. One study conducted in-depth interviews with WIC-eligible, pregnant Latina women (N=45, 78% enrolled in WIC) within Hartford County, Connecticut to identify barriers and facilitators to improved prenatal fruit and vegetable intake.[40] Women shared that, although friends and family had the largest influence on their fruit and vegetable intake, primary health care providers and WIC staff were also good sources for nutrition education, with one woman stating that "they [WIC] give you little brochures and like menus of tips of things that you can eat…." Women in the above-referenced study in Madison, Wisconsin[38] also reported that WIC policies targeting healthy foods enabled them to eat healthier, but some felt frustrated and embarrassed when using WIC vouchers. See Appendix D, Evidence Table D-143 for details.

Key Question 1a. Does the association of maternal and infant outcomes with WIC vary by gestational age at WIC enrollment or duration of mother's WIC participation?

Key Point

- The evidence was insufficient to determine whether maternal and infant outcomes varied by gestational age at WIC enrollment or duration of mother's WIC participation owing to the paucity of studies examining this question (SOE: Insufficient).

Maternal Health Outcomes

No studies addressed the association of maternal health outcomes by gestational age at WIC enrollment or duration of the mother's WIC participation.

Neonatal and Infant Birth Outcomes

For neonatal and infant outcomes, the evidence was insufficient on the association with gestational age at WIC enrollment or duration of mother's WIC participation owing to only one study assessing the relationships, as described below. [30]

Differences by Timing of WIC Enrollment

One retrospective cohort study linked to California Medicaid and WIC participation data (N=236,564; 2010) showed no dose-response relationship between **perinatal death (**defined by the study as fetal or infant deaths 20 through 46 weeks after the last menstrual period) and trimester of WIC initiation.[30]

Maternal Dietary Outcomes

No studies addressed the association of maternal dietary outcomes by gestational age at WIC enrollment or duration of the mother's WIC participation.

Key Question 1b. Does the association of maternal and infant health outcomes with WIC vary by participant factors such as age of the mother at delivery, race/ethnicity of mother, geographic location (e.g., region, urban vs. rural), education of the mother, employment status of the mother, marital status, or housing (e.g., public, homeless)?

Key Point

- Despite some specific studies suggesting that the relationship between WIC participation and maternal and infant health outcomes differs by racial and ethnic groups, the evidence was insufficient to draw conclusions on this question (SOE: Insufficient).

Maternal Outcomes

Differences by Race/Ethnicity

One single-state cohort study (N=275,482 women; 2004–2013) showed that although both groups had less **inadequate weight gain** associated with WIC participation, the association was somewhat stronger for Black women (-3.49% adjusted mean change; SE, 9.75%) than for White women (-2.64% adjusted mean change; SE, 9.78%).[24]

One large pre-post study used a difference in differences analysis of data from 2007–2012 to evaluate the 2009 food package change for WIC participants compared with the general population which includes both eligible and ineligible non-participants. They presented stratified analyses by race/ethnicity and evaluated several maternal health outcomes, including preeclampsia, gestational diabetes, and gestational weight gain.[25] For **gestational diabetes**, compared with White women, Black and Asian women experienced a slightly greater reduction in incidence (White women, 0.71% points; 95% CI, 0.27 to 1.1; Black women, -1.1% points; 95% CI, -2.0 to -0.24; Hispanic women, -0.31% points; 95% CI, -0.70 to 0.083; Asian women, -1.1% points; 95% CI, -1.9 to -0.22). In the same study, there were no statistically significant differences by race/ethnicity for the outcome of **preeclampsia**.[25] However, the study did report a reduction in the percentage of pregnancies with **excess gestational weight gain** (-3.2% points; 95% CI, -3.6 to -2.7), with the strongest effect for Black women as compared with White and Hispanic women (Black women, -5.5% points; 95% CI, -7.7 to -3.3; White women, -4.2%

points; CI, -5.2 to -3.2; Hispanic women, - 1.8% points; 95% CI, -2.7 to -1.0). Black women also experienced the greatest increase in achieving a total weight gain within the recommended range (3.8% points; 95% CI, 1.4 to 6.2), but the interaction term was not statistically significant.[25] Compared with White women, Hispanic and Asian women were also less likely to have inadequate gestational weight gain (White women, 2.0% points; 95% CI, 1.2 to 2.8; Hispanic women, 1.0% points; 95% CI, 0.35 to 1.7; Asian, 1.3% points; 95% CI, 0.095 to 2.7).

Despite these two studies suggesting differential association of selected maternal health outcomes with WIC by racial and ethnic subgroups, the evidence was insufficient to draw conclusions because of the paucity of studies reporting on the same outcome measures.

Neonatal and Infant Birth Outcomes

Differences by Race/Ethnicity

Regarding **stillbirth,** one nested case-control study used the Stillbirth Collaborative Research Network to identify stillbirth cases (defined as 18 weeks or later and meeting criteria for 'no sign of life') and live-born controls to assess the association between WIC participation (vs. non-WIC participation) and stillbirth or neonatal death by race/ethnicity (1,229 live births; 538 stillbirths), adjusting for insurance status and wage receipt (but not income).[41] They found that WIC participation was protective against **stillbirth** for Black women (adjusted OR, 0.31; 95% CI, 0.14 to 0.68), but not White women (adjusted OR, 1.49; 95% CI, 0.66 to 3.35) or Hispanic women (adjusted OR, 1.14; 95% CI, 0.67 to 4.37).[41]

Three studies assessed the association of **preterm birth** with WIC by race/ethnicity.[25, 26, 31] One large, pre-post study used a difference in differences analysis of data from 2007–2012 to evaluate the 2009 food package change (N=2,897,537 infants) for WIC recipients compared with the general population which includes both eligible and non-eligible non-participants. They showed no differences by racial/ethnic subgroups in **length of gestation** or **preterm birth**.[25] Another large national cohort study using birth certificate data (N=11,148,261 infants) showed WIC participation (vs. non-WIC participation) was associated with decreased risk of **preterm birth** after adjustment for sociodemographic characteristics, clinical risk factors, receipt of prenatal care, and maternal smoking; the study showed similar results by racial/ethnic subgroups (non-Hispanic White (adjusted OR, 0.90; 95% CI, 0.89 to 0.91), non-Hispanic Black (adjusted OR 0.88; 95% CI, 0.87 to 0.89), and Hispanic (adjusted OR, 0.91; 95% CI, 0.90 to 0.92).[26] One cross-sectional study used vital statistics natality data (2004–2012) from South Carolina (5,948 White mothers and 6,713 Black mothers) to conduct a stratified analysis and showed that WIC participation was associated with greater **gestational length** for Black versus White infants (3.5% vs. 1.9%, respectively).[31] Two large studies showed no racial/ethnic variation in the association of WIC participation with gestational age or risk of preterm birth, and one small single-state study showed racial/ethnic variation in this outcome.

Two studies assessed the association of WIC and **low birth weight** by race/ethnicity.[25, 31] In a stratified analysis from a South Carolina cross-sectional study, WIC participation (vs. non-WIC participation) was more protective for Black infants with a 63.0 g ($p<0.01$) increase in birth weight compared with White infants (38.6 g [$p< 0.01$]). Among Black and White infants, WIC was associated with a greater decrease in the adjusted probability of infants with **low birth weight** for Black versus White infants (-3.4% ($p< 0.01$) and -1.4% ($p<0.01$), respectively).[31] One large pre-post study used a difference in differences analysis of data from 2007–2012 (N=2,897,537 infants) to evaluate the 2009 food package change and showed that WIC

participation and the revised food package were differentially associated with **birth weight** in racial and ethnic groups.[25] Compared with the general population which includes both eligible and non-eligible WIC non-participants, Black and White women who were WIC recipients had reductions in their infants' birth weight, whereas Hispanic and Asian women who were WIC recipients had less reduction in their infants' birth weight compared with other race/ethnicity groups. These two studies showed conflicting evidence on the association of WIC participation with birth weight and risk of low birth weight for Black infants. Only one study, albeit large, reported differences in the association of WIC participation with birth weight for Hispanic, Asian, and other racial groups.

One cross-sectional study used vital statistics natality data from 2004 to 2012 from South Carolina to assess associations between WIC participation among 5,948 White mothers and 6,713 Black mothers and **NICU admission** for their infants.[31] Among Black and White infants, WIC was associated with a 1.7% ($p < 0.01$) and 1.5% ($p<0.01$) decrease in the probability of NICU admission, respectively.

Despite these studies suggesting differential association of infant health outcomes with WIC by racial and ethnic subgroups, the evidence was insufficient to draw firm conclusions because of a paucity of studies reporting similar associations with the same outcome measures.

Differences by Other Participant Characteristics

We also assessed differences in relevant outcomes by other participant characteristics when reported. One national cross-sectional study of PRAMS data (N=200,219 mothers; 2009–2017) assessed the moderating effect of WIC participation and Medicaid insurance together on the association between incarceration of a woman or her partner in the one year before childbirth (as a participant characteristic) and preterm birth.[42] After controlling for maternal race, age, college graduation, marital status, number of prior births, pregnancy planned, pre-pregnancy body mass index, income levels, state of residence, and year of birth, WIC and Medicaid together moderated the positive association between **preterm birth** and history of incarceration. The interaction term between incarceration and Medicaid showed a protective effect of WIC on **preterm birth** among women who had been incarcerated (OR, 0.820; 95% CI, 0.70 to 0.95). In addition, the same study showed that WIC and Medicaid together moderated the association between an infant with **low birth weight** and a maternal history of incarceration, indicating a protective effect of WIC and Medicaid (OR, 0.846; 95% CI, 0.746 to 0.959).

The evidence was insufficient to draw firm conclusions about how the association of maternal and health outcomes with WIC participation varied by other participant characteristics because of a paucity of studies addressing this question.

Maternal Dietary Outcomes

No studies addressed the association of maternal WIC participation with dietary outcomes by racial and ethnic subgroups or participant characteristics.

Key Question 2. Among infants and children eligible to participate in WIC, how is WIC participation associated with dietary and health outcomes in childhood?

Key Points

Infant and Child Health Outcomes

- Maternal WIC participation during pregnancy may be associated with reductions in infant mortality (SOE: Low).
- The evidence was insufficient to determine whether either maternal or child WIC participation was associated with the child health outcomes (including child mortality, morbidity and preventive care receipt) (SOE: Insufficient).

Child Anthropometric Status or Growth Outcomes

- The evidence was insufficient to determine whether child WIC participation was associated with overweight or obesity in children (SOE: Insufficient).

Breastfeeding Outcomes

- Maternal WIC participation may not be associated with breastfeeding initiation rate (SOE: Low).
- The evidence was insufficient to determine whether maternal or child WIC participation was associated with longer duration of any breastfeeding or with breastfeeding exclusivity (SOE: Insufficient).
- The evidence was insufficient to determine whether child WIC participation was associated with introduction of solids before 4 months of age (SOE: Insufficient).

Child Dietary Outcomes

- Child WIC participation is likely to be associated with greater child diet quality (SOE: Moderate).
- Child WIC participation is likely to be associated with greater intakes of 100 percent fruit juice, vegetables, infant cereal/grains, and age-appropriate shifts from whole milk to lower fat milk (SOE: Moderate).
- Household participation in WIC is likely to be associated with purchasing food of better diet quality and reduced purchasing of less healthy foods and beverages (SOE: Moderate).
- The evidence was insufficient to determine whether child WIC participation was associated with better nutrient intakes (SOE: Insufficient).
- The evidence was insufficient to determine whether living in a WIC household was associated with diet quality, food group intakes, or nutrient intakes in women (SOE: Insufficient).

Child Development and Academic Achievement

- Maternal WIC participation may be associated with higher child cognitive development scores (SOE: Low).

- The evidence was insufficient to determine whether child WIC participation was associated with cognitive development (SOE: Insufficient).
- The evidence was insufficient to determine whether either maternal or child WIC participation was associated with other child development outcomes (SOE: Insufficient).

Infant and Child Health Outcomes

Seven studies assessed the association of WIC participation with infant and child outcomes.[26, 43-48] One study examined the association of duration of WIC participation with recovery from anemia and is discussed in the section on Key Question 2a/b. The studies were too heterogeneous (in terms of study design, study population, and outcome measures) to support a meta-analysis. Table 7 presents the summary of findings and SOE from studies that most directly addressed the question regarding WIC participation and infant and child health outcomes. See Appendix D, Evidence Tables D-159 through D-182 for details.

Table 7. Summary of evidence on whether infant and child health outcomes were associated with maternal and/or child WIC participation compared with non-participants eligible for WIC

Outcomes	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Child mortality	0 studies	None	Inconclusive	Insufficient
Infant mortality	**2 studies** • 1 national cohort (11,148,261)[26] • 1 cross-sectional study (2,763)[43]	• Both studies found maternal WIC participation was associated with lower odds of infant mortality (OR range 0.58 to 0.84).	Maternal WIC participation may be associated with lower infant mortality.	Low • Study limitations: Medium • Directness: Direct • Consistency: Consistent • Precision: Precise
Morbidity- Health status	• 1 cross-sectional study of children up to 36 months of age (26,950)[44]	• Child WIC participation attenuated odds of caregiver reported fair/poor child health status and enhanced odds of well-child status in children exposed to family stressors.	Inconclusive	Insufficient • Study limitations: High • Directness: Indirect[b] • Consistency: Unknown • Precision: Precise
Morbidity- Hospitalization	• 1 cross-sectional study of children up to 36 months of age (26,950)[44]	• Child WIC participation did not attenuate odds of hospitalization in children exposed to family stressors.	Inconclusive	Insufficient • Study limitations: High • Directness: Indirect[b] • Consistency: Unknown • Precision: Precise
Anemia	0 studies	None	Inconclusive	Insufficient
Health care utilization- Preventive care visits	• 1 cohort study of children younger than 1 year (290,377)[45]	• Maternal WIC participation was associated with more well-child visits in the first year of life.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise
Health care utilization- Immunizations	• 1 cohort study of children younger than 1 year (290,377)[45]	• Maternal WIC utilization was associated with more vaccinations received within the first year of life per child.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Precise

Outcomes	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Health care utilization- Immunizations	**2 studies** • 1 cross-sectional national study of children ages 19–35 months)[46] • 1 cross-sectional national study of children ages 24–35 months (13,183)[47]	• Child WIC participation was associated with reduced odds of having 2 or more missed opportunities to receive the Hepatitis A vaccine. • Child WIC participation was associated with greater childhood immunization receipt, and higher coverage of measles, diphtheria, tetanus, and pertussis.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Consistent • Precision: Precise

OR = odds ratio; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Low SOE indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result, and insufficient SOE indicates that evidence is unavailable or does not permit a conclusion.
[b]The study examined whether WIC participation attenuated the relationship between stressors and developmental risk, not WIC impact on developmental risk.

Mortality

No eligible studies reported on the outcome of **child mortality**.

Two studies examined **infant mortality** (defined as death of a child younger than one year of age) associated with WIC participation during pregnancy.[26, 43] The studies used national or territory vital statistics and covariate adjustment procedures to derive comparisons regarding WIC participation, which was defined without details about duration or benefit issuance.

One national cohort study used birth certificate data (N=11,148,261) and showed that WIC live births, compared with eligible but non-WIC live births, had lower adjusted odds of infant mortality (adjusted OR, 0.84; 95% CI, 0.83 to 0.86; adjusted for sociodemographic characteristics, clinical risk factors, receipt of prenatal care, and maternal smoking).

A cross-sectional study examined the association of family and neighborhood poverty on infant health outcomes among 2,763 singleton infants born to mothers in Puerto Rico from 1994–1995 using Puerto Rican Maternal Infant and Health Survey data.[43] In an analysis adjusting for poverty level, prenatal care, and insurance, maternal self-reported WIC participation in pregnancy was associated with lower odds of **infant mortality** in the entire study population (adjusted OR, 0.58; $p<0.05$) and in the subset of the study population living below the poverty line (adjusted OR, 0.27; $p<0.001$). Because the association was not significant once infant low birth weight status was included in the regression models, the authors concluded that WIC participation reduced infant mortality by decreasing the incidence of low birth weight.

We concluded that maternal WIC participation may be associated with lower infant mortality. The SOE was low because there were only two studies, and they had medium study limitations, while results from the cohort study were precise and consistent with the cross-sectional study. See Appendix D, Evidence Tables D-159 and D-160 for details.

Morbidity

One cross-sectional study indirectly evaluated **child morbidity** associated with WIC participation.[44] This study analyzed Children's Health Watch data for children up to 36 months of age (N= 29,650; 2000-2010) and evaluated whether WIC participation attenuated the impact

of two stressors (household food insecurity and maternal depressive symptoms) on child health status and hospitalizations.[44] Child WIC participation was associated with attenuated odds of caregiver-reported fair/poor child health status and increased odds of well-child status among children with two versus fewer stressors. WIC participation was not found to attenuate the association between number of stressors and history of any caregiver-reported hospitalization (2 vs. 0 or 1 stressor): WIC participant adjusted OR, 1.29 (95% CI, 1.16 to 1.44); WIC non-participant adjusted OR, 1.40 (95% CI, 1.05 to 1.87). Because there is only one study and it indirectly evaluated the impact of WIC on this outcome, the SOE was insufficient to determine whether WIC participation was associated with morbidity as measured by hospitalizations. See Appendix D, Evidence Tables D-161 and D-163 for details.

Anemia

No eligible studies reported on the outcome of child anemia.

Health Care Utilization

Three studies reported on the association of WIC participation with infant and child health care utilization, including receipt of preventive care and immunizations.[45-47]

One large prospective cohort study examined the association between maternal prenatal WIC enrollment (which was considered a proxy for infant enrollment) and **receipt of preventive care** (number of well-child visits, probability of any well-child visit, and probability of meeting the recommendation for six well-child visits) among children younger than one year of age using South Carolina Medicaid and vital statistics data (N= 290,377; 2004 to 2013).[45] Maternal prenatal WIC participation was associated with increased well-child visit utilization in the child's first year of life compared with children without prenatal WIC participation (adjusted difference in **number of well-child visits**, 0.20; 95% CI, 0.16 to 0.23). This effect size was deemed important from a population health perspective, as any increase in well-child visits has potential to improve child outcomes. However, the SOE was insufficient given only one study with medium limitations.

Three studies reported on immunization receipt and showed a positive association between WIC participation and **immunization receipt**.[45-47] In the aforementioned prospective cohort study,[45] maternal prenatal WIC participation was associated with a small positive difference in the probability of receiving any vaccination in the first year of life (1.36%; SE, 0.365; $p<0.01$), and with a mean of 0.22 (SE, 0.0258; $p<0.01$) more vaccines obtained in one year of life, adjusting for maternal and child characteristics and maternal fixed effects. The two cross-sectional studies that used National Immunization Survey (NIS) data reported reduced odds of two or more missed opportunities for hepatitis A vaccination associated with current or former child WIC participation (OR, 0.59; 95% CI, 0.45 to 0.77; adjusted for child age and sex, maternal sociodemographic characteristics, household poverty level, geographic location, and immunization mandates).[46] The second study used NIS data to compare the prevalence of receipt of other vaccines including diphtheria, tetanus, pertussis, and measles vaccinations through 24 months of age for most years between 2007–2011.[47] Children currently in WIC were significantly more likely to be immunized than children formerly in WIC and those who were eligible but never participated. Because the difference in prevalence between WIC participants and eligible non-participants was on the order of 11 to 18 percent across the vaccines evaluated, this association was deemed important from a population health perspective. Immunization rates have a meaningful impact on future child and societal health. However, the SOE was insufficient

to determine whether maternal or child WIC participation was associated with immunizations because of the paucity of studies and study limitations. See Appendix D, Evidence Tables D-165 and D-166 for details.

Findings from Qualitative Studies About Infant and Child Health Outcomes

No eligible qualitative studies addressed the association of infant and child health outcomes.

Child Anthropometric Status or Growth

Eighteen studies assessed the association of WIC participation with a child's anthropometric status or growth outcomes.[22, 23, 44, 48-62] Only three studies directly compared risk-adjusted outcomes for WIC participants with eligible non-participants.[44, 48, 62] One study reported only unadjusted results for this comparison.[49] Eleven studies examined anthropometric outcomes of WIC children associated with the 2009 food package change. Three studies evaluated anthropometric outcomes related to duration of WIC participation (Key Question 2a).[22, 23, 48]

Studies that evaluated child weight status used body mass index z-score (BMIz), weight for length (WLZ, among children younger than 24 months of age) or weight-for-height (WHZ, 24 months and older), or weight-for-age z-scores (WAZ).[22, 23, 44, 48-50, 52, 53, 55-62] Children 2–4 years of age were classified as overweight or obese based on the Centers for Disease Control and Prevention (CDC) cut-points (BMIz between 85th and 95th percentile, and BMIz greater than or equal to 95th percentile, respectively). For younger children, WLZ was used, with values greater than or equal to the 95th percentile of the CDC reference considered indicative of high weight status.

Studies evaluating growth outcomes reported findings on linear growth using attained length- or height-for-age z-scores (referred to as LAZ or HAZ),[44, 48, 62] or head circumference z-score.[62] Five studies reported growth velocity outcomes.[52-55, 60] All of these growth studies compared anthropometric data with the CDC attained size reference charts.

Table 8 summarizes findings and SOE from the three studies that most directly addressed the question regarding WIC participation and anthropometric or growth outcomes. Table 9 summarizes information from the eleven studies of anthropometric and growth outcomes associated with the 2009 food package change, and which provide indirect evidence regarding the question about association of outcomes with WIC participation. The studies were too heterogeneous (in terms of study design, study population, and outcome measures) to support a meta-analysis. See Appendix D, Evidence Tables D-167 through D-174 for details.

Table 8. Summary of evidence on whether child anthropometric status or growth outcomes were associated with WIC participation compared with non-participants eligible for WIC

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Child weight status, overweight and obesity using BMIz, WLZ or WHZ	• 1 cross-sectional study of children up to age 36 months (26,950)[44]	• Child WIC participation was associated with a non-significant attenuation of odds of overweight status among children exposed to family stressors.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Precise

Growth velocity	0 studies	None	Inconclusive	Insufficient
Z-scores of length, height, weight or weight-for-length/height, continuous outcomes	• 1 difference-in-difference study of 1,222 maternal-child dyads before or after the 2009 food package change[61]	• Maternal WIC participation was associated with greater LAZ at age 12 months.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise
	• 1 cross-sectional study of children born preterm (71)[62]	• Child WIC participation was associated with greater mean WAZ at 24 months corrected age, but not for LAZ/HAZ or head circumference-for-age.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Imprecise

BMIz = body mass index z-score; HAZ = height-for-age z-score; LAZ = length-for-age z-score; WAZ = weight for-age z-score; WHZ = weight-for-height z-score; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WLZ = weight-for-length z-score.
[a]Insufficient strength indicates that evidence is unavailable or does not permit a conclusion.

Child Weight Status

Only two studies provided results comparing child overweight or obesity of WIC participants with non-WIC participants,[44, 49] and both studies focused on other exposures (early feeding practices[49], family stressors[44]). One of the studies reported only unadjusted associations.[49] Therefore, we were unable to draw a conclusion from these studies regarding child WIC participation and child anthropometric status or outcomes such as overweight or obesity in children 2 to 4 years of age. See Appendix D, Evidence Tables D-175, D-176, and D-178 for details.

Growth Velocity

No eligible studies were identified for this outcome.

Height, Weight, and Weight-for-Height Continuous Outcomes

Two studies reported associations with anthropometric outcomes as continuous measures.[61, 62] One study used longitudinal data on children from 2006–2010 whose mothers were enrolled during their pregnancies in the Conditions Affecting Neurocognitive Development and Learning in Early Childhood (CANDLE) study in rural Tennessee.[61] The study focused on self-reported prenatal participation in WIC and considered a birth that occurred after October 2009 to indicate some degree of exposure to the revised prenatal WIC food package. In analyses comparing WIC children with eligible non-WIC children and testing for the differential impact of the 2009 food package change (adjusting for multiple confounding factors), the authors reported a non-significant difference in WHZ (0.18; 95% CI, -0.16 to 0.52) and WAZ at 24 months of age (0.20; 95% CI, -0.10 to 0.51). For LAZ, the authors reported a significant difference at 12 months of age associated with WIC participation and the revised food package (0.33; 95% CI, 0.05 to 0.61) but no differences at 24 months of age or 6 years of age. A difference on the order of one-third of a standard deviation is likely to be clinically relevant and is relevant at the population level.

A cross-sectional study of 71 preterm (less than 37 weeks) infants attending a high-risk infant clinic at an urban hospital in California between 2013 and 2015 examined associations of WIC with or without SNAP participation and WAZ, HAZ, and head circumference for age (HCA) at 24 months of age.[62] The authors reported differences in mean WAZ for those in WIC or WIC

and SNAP compared with non-participants eligible for WIC (adjusted for race/ethnicity, education, language, birth weight, neonatal comorbidity, and post-discharge diagnosis): WIC versus none: 1.32 (95% CI, 0.42 to 2.21); and WIC and SNAP versus neither: 1.19 (95% CI, 0.16 to 2.23). Similar analyses resulted in a non-significant adjusted mean difference in HAZ of 1.02 (95% CI, -0.07 to 2.12) for those in WIC versus non-participants eligible for WIC, but a significant difference of 1.42 (95% CI, 0.19 to 2.65) for those in WIC and SNAP versus WIC-eligible non-participants in both programs. No significant differences were found for HCA z-score: for the WIC versus none group, 0.18 (95% CI, −0.97 to 1.33) and for the WIC and SNAP versus neither group, −0.11 (95% CI, −1.44 to 1.22). Differences in WAZ and HAZ greater than one standard deviation (SD) are clinically important.

Given the paucity of studies and the heterogeneity of populations studied across these outcomes, the SOE was insufficient to determine whether WIC participation was associated with these continuous anthropometric outcome measures. See Appendix D, Evidence Tables D-167 through D-172 for details.

Child Anthropometric Status or Growth Outcomes in 2009 Food Package Change Studies

Studies that compared outcomes among WIC participants before versus after the 2009 food package change provided indirect evidence regarding the question about the association of outcomes with WIC participation. The findings from 11 studies are presented in Table 9.

Table 9. Summary of evidence on the association of the 2009 food package change with child anthropometric status or growth outcomes in WIC participants

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of evidence (Rationale)[a]
Child weight status, overweight and obesity using BMIz, WLZ or WHZ	**3 studies of trends including pre-post 2009 food package changes using the same national data source with overlapping participants** • WIC children ages 2–4 years, 2000–2014 (22,553,518)[51] • WIC children ages 2–4 years, 2010–2016 (12,403,629)[50] • WIC children ages 2–4 years, 2000–2014 (16,868,936)[59] **6 longitudinal studies of WIC children:** • 5 from Los Angeles County, California using the same data	• Obesity prevalence increased from 2000–2009, but decreased from 2010–2014.[51, 59] • Overweight prevalence declined from 2010–2016. Declines in obesity prevalence were smaller but statistically significant. Similar declines were seen at each age from 2–4 years.[50] • Revised food package associated with lower risk of obesity from ages 1–4 years in 3 of 4 studies. • Revised food package associated with lower risk of obesity at age 4 years across strata of initial WLZ.	The 2009 food package change may be associated with lower risk of overweight or obesity among WIC children ages 2–4 years, which is indirect evidence of a relationship between WIC participation and these outcomes.	Low • Study limitations: Medium • Directness: Indirect • Consistency: Consistent • Precision: Precise

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of evidence (Rationale)[a]
	source: (182,618)[54]; (74,781)[52]; (116,991)[53]; (260,935)[55]; (106,150)[60] • 1 from New York State (260,935)[56] • **2 cross-sectional** studies of WIC children: in New York (3,562,184)[57]; in Los Angeles County, California (148,634)[58]	• Revised food package (less than fully breastfeeding, some formula or all formula fed) associated with lower risk of obesity at age 4 years. • Revised food package (for fully breastfeeding) was not associated with risk of obesity at ages 3–4 years.		
Growth velocity velocity of WLZ (before 24 months) or WHZ (24 months and older)	5 longitudinal studies of WIC children from Los Angeles County, California using the same data source (182,618)[54]; (74,781)[52]; (116,991)[53]; (260,935)[55]; (106,150)[60]	• Revised food package associated with slower WLZ velocity from ages 6–12 months in one study[54] and this dip was positively associated with duration of receipt of fully breastfeeding package.[60] • For infants not receiving the fully breastfeeding package, revised food package was associated with slower WLZ or WHZ velocities, in one study[53] but not in another.[52] • Revised food package associated with slower WLZ or WHZ velocities from ages 1–5 years across initial WLZ strata.[60]	The 2009 food package change may be associated with slower WLZ or WHZ growth velocity between ages 0 and 4 years, which is indirect evidence of a relationship between WIC participation and these outcomes.	Low • Study limitations: Medium • Directness: Indirect • Consistency: Consistent • Precision: Precise

BMIz = body mass index z-score; HAZ = height-for-age z-score; LAZ = length-for-age z-score; WHZ = weight-for-height z-score; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WLZ = weight-for-length z-score
[a]Low strength indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result.

Three studies analyzed national WIC participant characteristics data to compare age, sex, and race-adjusted trends in the **prevalence of overweight or obesity** among WIC-participating children 2 to 4 years of age.[50, 51, 59] The results are reported through 2016. Although time periods differed somewhat across studies, the trends in prevalence of child overweight or obesity from 2000–2009 changed after 2009 or 2010, with flattening or decreasing trends in prevalence. Two studies reported results overall and by state, demonstrating consistency in these findings across state or state agencies.[50, 59] One study[50] reported consistent changes in prevalence between 2010 and 2016 for children 2, 3, and 4 years of age. Overweight prevalence declined three percent and

obesity prevalence declined two percent, and significant reductions in overweight and obesity were seen overall and among age, sex, and racial/ethnicity subgroups (see Key Question 2b). See Appendix D, Evidence Tables D-175, D-177, D-179, D-180, and D-181 for details.

Eight studies of WIC participating children before or after the 2009 food package change evaluated **high weight status** and some considered the duration and timing of exposure to the revised food package (see also Key Question 2a).[54] Using cross-sectional six-month cuts of data from New York State WIC, the prevalence of overweight and obesity at 4 years of age declined after the 2009 food package change and were each 3 percent lower, and prevalence of high WLZ at 1 to 2 years of age was 6 percent lower in 2011 compared with 2008.[57] In Los Angeles County, California, using data on children matched across gender, race/ethnicity, maternal education and language, family income and initial weight status, exposure to the revised food package from 0 to 4 years of age was associated with reduced risk of obesity at 4 years of age by 10 percent (RR for boys, 0.88; 95% CI, 0.86 to 0.91; RR for girls, 0.90; 95% CI, 0.87 to 0.93) compared with the same duration of exposure to the food package before 2009.[54] Using this matched sample, another report from Los Angeles County, California found that exposure to the revised versus the pre-2009 food package was significantly associated with reduced risk of obesity at 4 years of age across all strata of WLZ at enrollment (low, average, high) for boys (relative risk (RR), 0.86 to 0.90) but only for average WLZ for girls (RR, 0.84).[60] Another report from Los Angeles County, California found that the neighborhood food environment modified the risk of obesity at 4 years of age when comparing the revised versus the pre-2009 food package for girls but not boys.[58] However, in a longitudinal study of WIC children in New York State, getting the revised food package during the first year of life (all children had the revised package from 1 to 3 years of age) did not significantly affect obesity risk at 3 years of age.[56] See Appendix D, Evidence Tables D-173 for details.

Results from several of these studies indicated that differences in the **risk of obesity** at 4 years of age varied by the type of food package received. In general, there was a higher risk of obesity at 4 years of age among those receiving formula during infancy as compared with those who were fully breastfed.[53, 56] Using matched samples of WIC children in Los Angeles County, California (as above, but also matched on food package status), one study reported that, among those fully formula fed, each additional year of exposure to the revised food package reduced risk of obesity at 4 years of age by one to two percent.[52] At 4 years of age, the **risks of overweight and obesity** were significantly reduced (RR for overweight, 0.93; 95% CI, 0.89 to 0.98; RR for obesity, 0.94; 95% CI, 0.89 to 0.99).[52] See Appendix D, Evidence Tables D-175, D-177, D-179, D-180, and D-181 for details.

In another report from that study, no differences in risk of obesity were found comparing the revised versus the pre-2009 fully breastfed package, but reduced risk was found when comparing the revised versus the pre-2009 food package among those less than fully breastfeeding or with some formula feeding.[53] Another study from the same population reported that longer duration of receipt of the fully breastfed package was associated with lower risk of obesity at 4 years of age (most protective RR, 0.73, 95% CI, 0.64 to 0.82, at 7 months receipt duration), adjusting for child age, sex, year of birth, birth order, maternal education, race/ethnicity, language, and family poverty level.[55]

Five reports evaluated **child growth velocity** (differences in WLZ or WHZ growth trajectories) before versus after the 2009 food package change to estimate the risk of overweight and/or obesity at 2 to 4 years of age. These reports also used data from a longitudinal study of participating WIC children in Los Angeles County, California.[52-55, 60] To compare the growth

velocity of those receiving the full dose revised food package with those receiving the full dose pre-2009 food package,[54] piecewise linear spline mixed models were fit using 6-month or 12-month periods, and interactions were fit to test for differences in velocity by revised versus pre-2009 food package received. Growth velocities were similar regardless of food package during the first 6 months of life, but large differences were observed during the second half of infancy, with infants exposed to the revised food package exhibiting a slower WLZ or WHZ velocity compared with those exposed to the pre-2009 food package (-0.413 with SD 0.031 for boys, and -0.439 with SD 0.030 for girls).[54] A difference on the order of 0.4 of an SD in WLZ velocity is striking and clinically significant and may be related to changes made by the revisions in specific infant food packages (see below). After the first year, the growth velocities were not generally different but did point to slower velocities in children receiving the revised food package versus the pre-2009 food package from 3 to 4 years of age. See Appendix D, Evidence Table D-173 for details.

The same modeling techniques for **growth velocities** were used to compare the revised food package with the pre-2009 food package from 0 to 5 years of age in analyses stratified by the type of infant package received and the child's sex.[53] Among those receiving the fully breastfeeding package, the 2009 food package change was associated with no differences in WLZ or WHZ. However, for the mostly breastfed, mostly formula fed, and fully formula fed groups, receipt of the revised food package was associated with slower WLZ velocities from 6 to 12 months of age, and this was generally true for both boys and girls. The study concluded that differences in velocities in the second half of infancy set up the growth patterns which led to the observed lower risk of obesity at 4 years of age. Following up infants who received the fully formula feeding package,[52] the authors identified only small and mostly non-significant food package change related differences in WLZ or WHZ velocities, except when comparing 4 years of exposure to the revised versus the pre-2009 food package. See Appendix D, Evidence Table D-174 for details.

One study compared growth patterns of children by the duration of receipt of the fully breastfeeding package.[55] The authors reported that longer exposure to the fully breastfeeding package was associated with faster WLZ velocities from 0 to 6 months of age and slower velocities from 6 to 12 months of age, which led to lower mean WLZ at 1 to 2 years of age. No effect modification was seen by receipt of the revised food package on these growth trajectories.

In analyses evaluating the modifying effect of initial WLZ status category (low, average, high) on the association of exposure to the revised or the pre-2009 food package,[60] the differences in growth velocities by food package did not vary by initial WLZ status. See Appendix D, Evidence Tables D-175, D-177, and D-181 for details.

In summary, evidence suggests that the 2009 food package change may be associated with significantly lower risk of **overweight and obesity** in WIC-enrolled children who are 2 to 4 years of age. The SOE was low for the prevalence studies based on medium study limitations, indirect relation to the Key Question, consistency across studies, and precise findings. None of these studies addressed secular trends as a significant risk of bias. The studies evaluating the 2009 food package change and risk of obesity used matched samples of WIC children and/or additional covariate adjustment that provide more rigorous indirect evidence regarding the Key Question. A limitation is that the evidence consists of multiple reports from two sites, so the SOE was low. The clinical significance of the declining annual prevalence of overweight of 2 to 3 percent among children 2 to 4 years of age or a lower risk of overweight or obesity (by 10% at 4 years of age) is not clear. However, the trends are important from a policy perspective because

the 2009 food package changes were enacted in part to address the increasing prevalence of obesity among WIC participants. A caveat to the conclusion may be that the type of infant food package matters. Studies from two locations suggest that the 2009 food package change was associated with reduced risk at 4 years of age among those receiving infant formula (fully formula fed, some formula, less than fully breastfed), whereas the change did not affect risk among those receiving the fully breastfeeding package (who were at lower risk of obesity in general).

Evidence suggests that the 2009 food package change may be associated with **reduced WLZ velocity** in WIC children at various time points from 0 to 4 years of age. The studies had medium limitations, indirect relation to the Key Question, consistent findings, and precision in the results, but all the studies originated from the same WIC setting in Los Angeles County, California. Taken together, these limitations support a conclusion of low SOE regarding a clinically important slowing of WLZ velocity from 6 to 12 months of age, and slower velocities from 3 to 4 years of age. Receipt of the revised versus the pre-2009 food package was associated with differences in growth velocities by type of infant food package received, with the revised food package associated with slower velocities for children not receiving the fully breastfeeding package. Greater duration of receipt of the fully breastfeeding package was associated with much slower WLZ velocity in later infancy.

Findings from Qualitative Studies About Child Anthropometric Status or Growth Outcomes

No qualitative studies addressed the association of WIC participation with a child's anthropometric status or growth outcomes.

Breastfeeding Outcomes for Key Question 1 and Key Question 2

Breastfeeding outcomes were combined for Key Question 1 and Key Question 2 because these outcomes are relevant for both maternal and child health and because these outcomes could be related to WIC participation of the mother and/or the child. Twelve studies assessed WIC participation and breastfeeding initiation, duration, and exclusivity. One study assessed breastfeeding intention.

Table 10 summarizes findings and SOE from the five studies that most directly addressed the question regarding WIC participation and breastfeeding outcomes. Table 11 summarizes information from the seven studies of breastfeeding outcomes associated with the 2009 food package change, and which provide indirect evidence regarding the question about association of breastfeeding outcomes with WIC participation. The AAP recommends that solid foods not be introduced until about 6 months of age, and the first 6 months is the recommended period of exclusive breastfeeding.[8] Therefore, in this section, we have included one study of the association between the early introduction of complementary foods and WIC participation and two studies of early introduction of solid foods associated with the 2009 food package change. This section also reports on the association of prenatal intention to breastfeed and the 2009 food package change (one study) and the receipt of WIC breastfeeding services and breastfeeding outcomes among WIC participants (two studies). The studies of breastfeeding outcomes were too heterogeneous (in terms of study design, study population, and outcome measures) to support a meta-analysis. See Appendix D, Evidence Tables D-183 through D-197 for details.

Table 10. Summary of evidence on whether breastfeeding outcomes were associated with WIC participation during pregnancy (KQ1) and in childhood (KQ2) compared with non-participants eligible for WIC

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of evidence (Rationale)[a]
Breastfeeding initiation	**4 studies** 3 population cohorts (from 2 studies) • PRAMS, 19 states (127,477)[63] • NIS national (73,991)[63] • NHANES, WIC eligible children 0-59 months 2000–2008 and 2009–2014 (4,308)[64] **2 postpartum cohorts, South Carolina** • 1 birth certificates, 2004–2013 (271,096)[24] • 1 PRAMS, 2009–2010 (1,238)[27]	• No difference in breastfeeding initiation rates between WIC and non-WIC groups.[63, 64] • Breastfeeding initiation rates have increased over time for WIC participants but increase not different from non-WIC rates. • WIC participation associated with 1.48% increased initiation,[24] but lower risk in another study from same population.[27]	WIC participation may not be associated with breastfeeding initiation.	Low • Study limitations: Medium • Directness: Direct • Consistency: Inconsistent • Precision: Precise
Breastfeeding Duration	**2 studies** • NHANES: WIC eligible children 0-59 months 2000–2008 and 2009–2014 (4,308)[64] • PRAMS data, South Carolina, 2009–2010, (1,238)[27]	• Child WIC participation was associated with lower prevalence of breastfeeding at age 6 months.[64] • Among those who initiated breastfeeding and evaluated through 30 weeks, no difference by maternal WIC participation in the hazard ratio for discontinuing breastfeeding after adjustment for socioeconomic and other factors.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Inconsistent • Precision: Imprecise
Breastfeeding exclusivity	• 1 population cohort, NIS national: (127,477)[63]	• No difference in exclusive breastfeeding at age 3 months by WIC participation.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise
Introduction of solids before age 4 months	• 1 population cohort, NHANES: WIC eligible children 6-36 months 2009–2014 (936)[65]	• Prevalence of solids introduction before age 4 months is declining and no difference by WIC participation.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise

NIS = National Immunization Survey; NHANES = National Health and Nutrition Examination Survey; PRAMS = Pregnancy Risk Assessment Monitoring System; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Low strength indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result, and insufficient evidence indicates that evidence is unavailable or does not permit a conclusion.

Breastfeeding Initiation

Four studies compared breastfeeding initiation between WIC participants and income-eligible non-WIC participants using national or multi-state surveys and birth certificate data.[24, 27,

[63, 64] Breastfeeding initiation was most often assessed through maternal responses to queries about whether the infant was ever breastfed or ever received breast milk. One study assessed breastfeeding status at hospital discharge as a surrogate for initiation.[24] These studies also used data over time to examine potential impact of the 2009 food package change. In two of the studies (using 3 data sources),[63, 64] prior to the 2009 food package change, WIC participation was negatively associated with breastfeeding initiation, and in the latter period, the differences were no longer statistically significant. In the PRAMS data from 19 states, the initiation rate increased 2.8 percent more among WIC participants comparing 2010 with 2004–2007, but this difference was only -0.08 percent in the NIS survey.[63] Two studies from South Carolina provided conflicting results.[24, 27] In line with the national studies, the South Carolina study using birth certificate data found a 1.48 percent higher rate of initiation among WIC participants (SE 0.4%, $p<0.05$). The second study over-sampled for low birth weight and preterm delivery and found WIC participation was negatively associated with initiation.[27] See Appendix D, Evidence Tables D-183, D-185, and D-187 for details.

The studies evaluating WIC participation and breastfeeding initiation generally found no difference in breastfeeding initiation rates by WIC participation. We graded the SOE as low with respect to WIC participation and breastfeeding initiation based on medium study limitations, inconsistency across studies, and relatively precise findings.

Breastfeeding Duration

Two studies compared breastfeeding duration between WIC participants and income-eligible non-WIC participants.[27, 64] Both studies also compared breastfeeding duration before and after the 2009 food package change, but they used different measures of duration. One national study evaluated the prevalence of any breastfeeding at 6 months of age and found no difference by WIC participation.[64] The other study, from South Carolina, used survival analysis to examine the probability of discontinuing breastfeeding through 30 weeks of age. In adjusted analysis, WIC participants were more likely to discontinue breastfeeding, but this difference became non-significant with adjustment for socioeconomic and other characteristics.[27] See Appendix D, Evidence Tables D-189 and D-191 for details of the outcome data.

Overall, the SOE was insufficient regarding WIC participation and duration of breastfeeding based on medium study limitations, inconsistency across studies, and relatively precise findings.

Breastfeeding Exclusivity

Only one study compared exclusive breastfeeding between WIC participants and income-eligible non-WIC participants. A national study using the NIS reported no difference in exclusivity by WIC participation.[63] Because there was only one study, which had medium limitations, the SOE was insufficient with respect to differences in breastfeeding exclusivity by WIC participation. See Appendix D, Evidence Table D-193 for details of the outcome data.

Early Introduction of Solid Foods

One study used national NHANES data from 2009–2014 to compare the early introduction of solid foods by WIC participants with that by income-eligible non-WIC participants.[65] In adjusted analyses, WIC participants were not more likely to introduce solids before 4 months of age than non-participants eligible for WIC. Because there was only one study, which had medium limitations, the SOE was insufficient to determine whether WIC participation was associated

with the prevalence of introduction of solid foods before 4 months of age. See Appendix D, Evidence Table D-195 for details.

Breastfeeding Outcomes in 2009 Food Package Change Studies

Studies that compared breastfeeding outcomes for WIC participants before versus after the 2009 food package change provided indirect evidence regarding the Key Question about the association of outcomes with WIC participation. The findings from seven studies are presented in Table 11.

Table 11. Summary of evidence on the association of the 2009 food package change with breastfeeding outcomes in WIC participants during pregnancy and in childhood

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of evidence (Rationale)[a]
Breastfeeding initiation	**6 studies** • National sample of 17 local WIC agencies (88,251)[66] • PedNSS: 16 states WIC infants (744) [63] New York State PedNSS • 1 comparison of 2008 and 2011 (1,007,318)[57] • 1 prospective trend analysis from 2002–2015 (about 110,000 per years); [67] From local agencies • Los Angeles County, California, repeated cross-sectional surveys with WIC participants: 2005 vs. 2008 vs. 2011 (5,020)[68] • South-central Texas cross-sectional survey: 2009 vs. 2011 (204)[69]	• No change in breastfeeding initiation comparing 1–2 months before 2009 food package change vs. 5–12 months after change.[66] • Gradual increase in breastfeeding initiation over time or no change over time, both suggesting no impact of 2009 food package change. • In one Los Angeles County study, there were higher odds of initiating breastfeeding in 2011 vs. 2008.[68]	The 2009 food package change may not be associated with breastfeeding initiation, which is indirect evidence of a relationship between WIC participation and this outcome.	Low • Study limitations: Medium • Directness: Indirect • Consistency: Inconsistent • Precision: Imprecise
Breastfeeding duration	**4 studies** • National sample of 17 local WIC agencies (115,068)[66] New York State PedNSS • 1 prospective trend analysis from 2002–2015 (about 110,000 per years); [67] From local agencies • Los Angeles County, California, repeated cross-sectional surveys with WIC participants: 2005 vs.	• Small or no change in prevalence of any breastfeeding at age 3 months in 3 studies. • One study found a significant 10% greater prevalence of infants receiving the fully breastfeeding package at age 3 months after the 2009 food package change. • Three studies found	The 2009 food package change may not be associated with breastfeeding duration, which is indirect evidence of no relationship between WIC participation and this outcome.	Low • Study limitations: Medium • Directness: Indirect • Consistency: Inconsistent • Precision: Precise

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of evidence (Rationale)[a]
	2008 vs. 2011 (5,020)[68] • South-central Texas cross-sectional survey: 2009 (84); 2011 (120)[69]	no change in the prevalence of any breastfeeding at age 6 months associated with the 2009 food package change.		
Breastfeeding exclusivity	**3 studies** • 1 prospective trend analysis from 2002–2015 (about 110,000 per years); [67] **From local agency Los Angeles County, California,** • Repeated cross-sectional surveys with WIC participants: 2005 vs. 2008 vs. 2011 (5,020)[68] • Monthly samples of infants (5,000) from 12/2007–10/2010[70]	• Revised food package associated with higher odds of exclusive breastfeeding at age 3 months and at age 6 months. • Rate of fully breastfeeding food package issuance increased with 2009 food package change at enrollment at age 2 months and at age 6 months. • Increase in crude prevalence of exclusive breastfeeding at ages 3+ months from 2006–2015 (8.9% to 14.3%) and at ages 6+ months from 2006–2010 (2.9% to 5.8%).	The 2009 food package change may be associated with breastfeeding exclusivity, which is indirect evidence of a relationship between WIC participation and these outcomes.	Low • Study limitations: Medium • Directness: Indirect • Consistency: Consistent • Precision: Precise
Introduction of solids before age 4 months	**2 studies** • 1 New York State WIC PedNSS (3,500,000)[57] • 1 local study in south-central Texas WIC (196)[69]	• Revised food package associated with decline in introduction of solid foods before age 4 months	Inconclusive	Insufficient • Study limitations: Medium • Directness: Indirect • Consistency: Consistent • Precision: Precise

CI = confidence interval; PedNSS = Pediatric Nutrition Surveillance System; PRAMS = Pregnancy Risk Assessment Monitoring System; OR = odds ratio; vs. =versus; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Low confidence that the evidence reflects the true effect, and further research is very likely to change the result and insufficient evidence indicates that evidence is unavailable or does not permit a conclusion.

Six studies evaluated changes over time in **breastfeeding initiation** among WIC participants only.[57, 63, 66-69]Trends from national and New York state WIC data showed either no change or graduated increases in breastfeeding initiation over time, similar to the changes described nationally and suggesting no change in the trend after the 2009 food package change.[57, 67] A national study examining the immediate impact of the 2009 food package change found no difference in initiation (65.5% vs. 65.1%; p=0.58).[66] However, among predominantly Hispanic WIC participants in Los Angeles County, California, a 2-fold higher adjusted odds of breastfeeding initiation was reported after the 2009 food package change (OR, 2.16; 95% CI, 1.69 to 2.76).[68] We graded the SOE as low with respect to WIC participation and the 2009 food package change based on medium study limitations, inconsistency across studies, and relatively precise findings. See Appendix D, Evidence Tables D-184, and D-186 for details.

Four studies assessed the 2009 food package change and prevalence of **any breastfeeding at 3 months of age** among WIC participants.[66-69] A national study among 17 local WIC agencies reported that receipt of full or partial breastfeeding packages declined significantly immediately after the 2009 food package change, suggesting a decline in any breastfeeding at 3 months of age.[66] In both Los Angeles County, California WIC and south-central Texas WIC groups, no significant change in any breastfeeding at 3 months of age was reported. The temporal trends study in New York State WIC found increased rates of any breastfeeding at 3 months of age, but a gradual increase from 2002–2015.[67] Thus, the results indicated no change in breastfeeding at 3 months of age associated with the 2009 food package change among WIC participants.

Four studies assessed the 2009 food package change and prevalence of **any breastfeeding at 6 months of age**.[66-69] Again, results mostly indicated no change in the prevalence of any breastfeeding at 6 months of age comparing before with after the 2009 food package change. The temporal trends in New York State breastfeeding from 2002–2015 indicated that the crude proportion of infants breastfed at 6 months of age has not increased since 2005.[67] However, a study from Los Angeles County, California found that issuance of the fully breastfeeding food package at 6 months of age increased 13.9 percent with the food package change.[70]

In general, the revised food package was not associated with a change in **breastfeeding duration** (any breastfeeding at 3 or 6 months of age). The SOE was low based on medium study limitations, some inconsistency across studies, and relatively precise findings. See Appendix D, Evidence Tables D-190 and D-192 for details.

Among studies of WIC participants and the 2009 food package change, three reported on prevalence of **breastfeeding exclusivity** at 2 to 3 months of age[67, 68, 70] and two on exclusivity at 6 months of age.[68, 70] One study reported that the revised food package was associated with a 1.72 (95% CI, 1.43 to 2.07) times greater likelihood of exclusive breastfeeding at 3 months of age, and a 3.08 (95% CI, 2.27 to 4.18) times greater likelihood of exclusive breastfeeding at 6 months of age.[68] In another study from the same local agency, the rate of fully breastfeeding issuance (no infant formula issuance) increased significantly ($p<0.001$) with the 2009 food package change at enrollment (23.8% to 44.2%), at 2 months of age (12.7% to 19.9%) and at 6 months of age (8.5% to 13.9%). Trend data from that study showed a rise in fully breastfed issuance in conjunction with the 2009 food package change.[70] Trends in breastfeeding exclusivity for 1 or more or 3 or more months were evaluated among infants in New York WIC and, although the prevalence increased significantly, changes were gradual over time, suggesting no difference related to the 2009 food package change.[67] See Appendix D, Evidence Tables D-190, D-192, and D-194 for details of the outcome data.

The SOE was low that the revised food package was associated with increased breastfeeding exclusivity among WIC participants based on consistency across the studies and relatively precise findings but medium study limitations.

One study evaluated changes in **prenatal breastfeeding intention** associated with the 2009 food package change in a predominantly Hispanic WIC population in Los Angeles County, California.[68] Unadjusted analyses showed a small but statistically significant increase in prenatal intention to breastfeed, from 84 percent in 2005 to 86 percent in 2008 and 88 percent in 2011 ($p=0.004$). Because there was only one study, the SOE was insufficient with respect to the association between prenatal intention to breastfeed and the 2009 food package change. See Appendix D, Evidence Table D-188 for details of the outcome data.

Two studies compared **introduction of complementary foods** before and after the 2009 food package change among WIC participants.[57, 69] Administrative data from New York State

WIC reported declines in the prevalence of solid food introduction before 4 months of age after the 2009 food package change.[57] A study from a south-central Texas WIC clinic reported that the age of complementary food introduction was two weeks later after the 2009 food package change. In addition, fewer caregivers in 2011 reported ever adding infant cereal to their child's bottle (39% vs. 21.4%; p<0.01) and a smaller proportion of children 4 to 6 months of age were exposed to infant cereal (47.1% vs. 30.4%). There were no differences in early exposure to juice before 4 months of age (4.9% vs. 10.7%) or between 4 to 6 months of age (21.3% vs. 21.4%). Because of the limited number of studies, the SOE is insufficient to draw conclusions regarding association of the revised food package with the introduction of solid foods before 4 months of age. See Appendix D, Evidence Tables D-196 and D-197 for details.

Receipt of WIC Breastfeeding Support Services

One study from Minnesota evaluated specific WIC services to support breastfeeding and breastfeeding initiation.[71] The study found 1.66 times (95% CI, 1.19 to 2.32) higher odds of breastfeeding initiation for those who received a prenatal peer counselor contact.[71]

Two studies evaluated specific WIC services to support breastfeeding and breastfeeding duration.[71, 72] A national study of breastfeeding support services reported 20 percent higher odds of any breastfeeding at 6 months of age per support service. A study from Minnesota reported that prenatal peer counselor contacts were associated with a lower risk of discontinuing breastfeeding from birth through 12 months of age.[71] Among WIC participants, the availability or receipt of support services was associated with longer duration of breastfeeding with evidence up to 12 months of age. The SOE for this outcome was low based on medium study limitations, indirect relationship to the key question, consistent findings across studies and time points, and relatively precise findings. See Appendix D, Evidence Tables D-189 and D-191 for details.

Finally, a national study evaluating the number of breastfeeding supports available to participants reported 20 to 40 percent higher odds of an infant fully breastfed at 2 and 6 months of age per service available.[72] Based on having only one study, which had limitations, the SOE was insufficient to conclude whether the availability of breastfeeding support services increased exclusivity of breastfeeding among WIC participants.

Findings from Qualitative Studies About Breastfeeding

We identified nine qualitative studies that reported on breastfeeding perceptions among WIC participants.[73-81] The studies employed either focus groups[73, 75, 76, 80, 81] or semi-structured interviews.[74, 77-79] One study focused on experiences of WIC participants who breastfed (n=17) compared with those who formula fed (n=14).[73] Six of these studies examined experiences among subpopulations who experience disparities in breastfeeding rates, including African American women,[74, 79] Hispanic women,[77] rural women,[80] and immigrant women.[75] One focus group study concentrated on perceptions of African American WIC participants from the point of view of WIC peer counselors (n=23).[76] Another focus group study sought to understand WIC strategies to promote breastfeeding in Puerto Rico from the perception of WIC nutritionist-dietitians (n=29).[81] One mixed-methods study[78] sought to understand the influence of changes in the 2009 food package (n=52).

The studies reported overall positive cultural attitudes about breastfeeding among Hispanic women,[77] and Marshallese immigrants.[75] However, both groups reported a perception that the U.S. culture did not approve of breastfeeding, and participants expressed feeling ashamed of breastfeeding in the United States. Hispanic and Marshallese immigrants noted that WIC helped

to provide education on breastfeeding and related nutrition recommendations. WIC also provided access to formula that participants may not have had in their country of origin and this was a major driver in the decision to formula feed instead of breastfeeding.

In contrast, in another study, some mothers who elected to formula feed felt judged or left out because of a perceived emphasis on breastfeeding in the WIC program.[80] Others experienced conflicting information about breastfeeding from WIC staff and physicians[80] or just lack of information from physicians.[79] For example WIC peer counselors and midwives were mentioned as providing more education and encouragement to breastfeed than obstetricians who remained silent when asked about breastfeeding.[79]

In a study exploring the 2009 food package change, some women viewed the revised food package for exclusive breastfeeding as positively influencing their choice to breastfeed, but a majority noted that it did not influence their decisions.[78] Some noted that their decision to breastfeed was based on other reasons (such as the health of the baby) and some noted that they would breastfeed regardless of whether there were nutritional or economic incentives in the food package.

In two focus group studies, African American WIC participants expressed that social support was among the most important factors that influenced initiation and duration of breastfeeding.[74, 79] The few participants that accessed WIC-related breastfeeding support services (e.g., lactation counselor) had a positive experience, but many participants reported being unaware of WIC services related to breastfeeding support and some expressed a desire to have peer role models who have breastfed long term.[79] In another study focused on the experiences of African American WIC participants, WIC peer counselors reported that historical factors (e.g., slavery and black women's role as wet nurses), community perceptions of breasts as sexual organs not as a source of nutrition, as well as norms of black womanhood (e.g., strong black women may not ask for help) created resistance to breastfeeding.[76] In a study of nutritionist-dietitians from Puerto Rico, barriers to breastfeeding initiation included media and marketing and hospital resources that seem to support and/or glamorize bottles, pacifiers, and other accessories not aligned with breastfeeding success.[81] In this context, the WIC program was a valuable (and often the sole) source of education and support for participants. See Appendix D, Evidence Table D-143 for details of the data.

Child Dietary Outcomes

Various indices were used to examine dietary outcomes in children, including overall diet quality using the HEI score and a variety of individual food group and nutrient intake indices. Nineteen studies examined associations between WIC participation and child dietary intakes. Six studies examined whether dietary intakes differed by WIC participation versus non-participation by those eligible for WIC, and are presented in Table 12.[82,83-87] Ten studies examined changes in dietary intakes of WIC children only associated with the 2009 food package change,[88-89, 57, 69, 90, 91, 92, 93] and represent indirect evidence with respect to the Key Question. These studies are presented in Table 13. Finally, three studies examined whether dietary outcomes differed by duration of WIC participation and are described in Key Question 2a.[22, 94, 95] The studies were too heterogeneous (in terms of study design, study population, and outcome measures) to support a meta-analysis. See Appendix D, Evidence Tables D-198 through D-278 for details.

Table 12. Summary of evidence on whether diet quality, food group intakes, and nutrient intake outcomes for children were associated with WIC participation compared with non-participation by those eligible for WIC

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Child diet quality measured by the HEI-2010	**2 studies** • 1 national cross-sectional study [NHANES] of children ages 2–4 years, 2003–2008 vs. 2011–2012 (1,197)[82] • 1 national cross-sectional study [NHANES] of children ages 2–4 years, 1999–2012 (6,151)[85]	• WIC participation associated with 3.7- to 4.5-point higher HEI-2010 scores[82,85]	Child WIC participation is likely to be associated with greater diet quality.	Moderate • Study limitations: Medium • Directness: Direct • Consistency: Consistent • Precision: Precise
Food group intake	**3 studies** • 1 national cross-sectional study [FITS] of children ages 6–47 months in 2016 (1,702)[83] • 1 national cross-sectional study [NHANES] of children ages 12–23 months, 2011–2014 (286)[87] • 1 national cross-sectional study [NHANES] of children ages 2–4 years, 2009–2014 (1,086)[86]	• WIC participants at ages 6–11 months were 1.29 times more likely to consume infant cereal and 2.84 times more likely to consume baby food vegetables.[83] • WIC participants at ages 11–23 months had greater consumption of grains (+9%) and vegetables, excluding potatoes (+15.8%).[87] • WIC participants at ages 12–23 months were 1.43 times more likely to consume whole milk, and those ages 24–47 months were 2.92 times more likely to consume non-fat or 1% milk.[83] • All three studies found WIC participants were significantly more likely to consume 100% juice.	Child WIC participation is likely to be associated with greater intakes of 100% fruit juice, vegetables, infant cereal/grain intake, and age-appropriate shifts from whole milk to lower fat milk.	Moderate • Study limitations: Medium • Directness: Direct • Consistency: Consistent • Precision: Precise
Nutrient Intakes	• 1 cross-sectional national study [FITS] of children ages 6–47 months in 2016 (1,453)[84]	• WIC participants had higher intakes of vitamin D at all ages, greater intakes of iron at ages 6–11 months, and more WIC participants (+6.2%) met the saturated fat recommendation at ages 24–47 months.[84]	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise

CI = confidence interval; FITS = Feeding Infants and Toddlers Study; HEI = Healthy Eating Index; NHANES = National Health and Nutrition Examination Survey; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Moderate strength indicates that further research may change the result, and insufficient evidence indicates that evidence is unavailable or does not permit a conclusion.

Child Diet Outcomes

Two studies used national data from NHANES to evaluate **diet quality**.[82, 86] One study[82] compared HEI-2010 scores from 2003–2008 with scores from 2011–2012 between WIC participants and income-eligible non-participants 2 to 4 years of age. After the 2009 food package change, WIC participation was associated with a 3.7 points higher mean HEI-2010 score (95% CI, 0.6 to 6.9) than the mean score of eligible non-WIC participants. This study also reported higher component scores as the ratio of relative change for WIC participants versus income-eligible non-participants, with higher scores for greens and beans (3.4; 95% CI, 1.3 to 9.4), whole grains (1.6; 95% CI, 0.9 to 2.6), and fatty acids (1.3; 95% CI, 1.0 to 1.8). No significant associations were found for the other component scores. The other study used NHANES data from 1999–2012,[85] and analyzed trends in HEI-2010 scores over time among children 2 to 4 years of age by WIC participation. From 1999–2012, HEI-2010 scores increased in both groups (linear trend $p<0.001$). In 2011–2012, with the revised food package, WIC participants had an approximately 4-point higher mean diet quality score (55.8; 95% CI, 53.9 to 57.8) than income-eligible non-participants (51.3; 95% CI, 48.9 to 53.7). This study did not evaluate diet quality component scores. Thus, WIC participation is likely to be associated with better child diet quality. The use of nationally representative data, standardized methods, covariate adjustment, and precision of the estimates supported a moderate SOE for this conclusion. See Appendix D, Evidence Table D-198 for details.

Three studies compared **food group intakes** of WIC participants with income-eligible non-participants.[83, 86, 87] These studies used national data from the Feeding Infants and Toddlers Study (FITS) or NHANES. In one study,[83] intakes of food groups were compared at three ages: 6 to 11, 12 to 23, and 24 to 47 months. Compared with income-eligible non-participants, WIC participants 6 to 11 months of age were more likely to consume infant cereal (OR,1.29; 95% CI, 0.91 to 1.81) and baby food vegetables (OR, 2.84; 95% CI, 2.00 to 4.04); WIC participants at 12 to 23 months of age were more likely to consume whole milk (OR, 1.43; 95% CI, 1.00 to 2.03), and WIC participants at 24 to 47 months of age were more likely to consume low or non-fat milk (OR, 2.92; 95% CI, 1.76 to 4.85). WIC participants 6 to 47 months of age were more likely than income-eligible non-participants to consume juice (OR, 2.74; 95% CI, 1.62 to 4.64). Another study[87] used NHANES data and focused on children 12 to 23 months of age. This study reported greater percentages of children in WIC versus income-eligible non-WIC children consuming grains (85.5% vs. 76.5%, $p<0.05$), vegetables other than potatoes (58.1% vs. 42.3%, $p<0.05$), and 100% juice (70.6% vs. 51.6%, $p<0.05$). Conversely, fewer WIC children (91.7%) consumed dairy than income-eligible non-WIC children (97.2%; $p<0.05$), but no differences were seen between groups in type of milk (i.e., whole vs. reduced fat) consumed. Another study[86] used NHANES data and examined WIC participation and food group intake for children 2 to 4 years of age. WIC participants consumed more total fruit (including 100% fruit juice) (β, 0.30 cup-equivalents per day; 95% CI, 0.04 to 0.57) and more 100 percent fruit juice (β, 0.22 cup-equivalents per day; 95% CI, 0.04 to 0.40) but not more whole fruit or total vegetables than income-eligible non-WIC children. See Appendix D, Evidence Tables D-220, D-222 through D-226, D-229, D-233, D-235, D-236, D-240, D-242, D-245, D-247, D-248, D-250, D-252, D-255, D-259, D-261, D-263, D-266, and D-268 for details.

Overall, the results indicated that WIC participation was associated with greater intake of healthy food group options compared with income-eligible non-WIC children. These included greater intake of 100% fruit juice, vegetables (primarily in the form of baby food vegetables), infant cereals/grains, and age-appropriate patterns of milk intake (i.e., whole fat milk from 12 to

23 months of age and low-fat or non-fat milk from 24 months of age onward). The SOE for this conclusion was moderate because of the use of national data, standardization of methods in the studies, consistency of expected differences by child age, the degree of covariate adjustment, and consistency between studies. These studies reported on intakes of specific food groups prioritized in nutrition education and through the WIC food package benefits. See Appendix D, Evidence Tables 142 through 200 for details.

One study used national FITS data from 2016 to compare **nutrient intakes** of WIC participants with income-eligible non-WIC participants.[84] They evaluated intakes with respect to the Dietary Reference Intakes by age strata (ages 6 to 11 months, 12 to 23 months, and 24 to 47 months). More WIC participants had adequate vitamin D status at all ages ($p<0.05$). At 6 to 11 months of age, more WIC participants had intakes above the Adequate Intake level (23.7% vs. 8.2%). After 12 months, more WIC participants met the Estimated Average Requirement (EAR) (at 12 to 23 months of age: 23.9% vs. 17.4%; at 24 to 47 months of age: 20.7% vs. 11.3%). More WIC participants at 6 to 11 months of age met the EAR for iron intake (87.4% vs. 74.4%, $p<0.05$). However, fewer WIC participants at 12 to 23 months of age met the EAR for calcium intake (89.3% vs. 94.1%, $p<0.05$), and WIC participants were also more likely to exceed limits on added sugars (7.9 % vs. 2.4%, $p<0.001$). WIC participants at 24 to 47 months of age were more likely to meet the recommended intake of saturated fat (61.0 % vs. 67.2%, $p<0.05$). Despite several differences in nutrient intakes, the presence of only one study comparing nutrient intakes of WIC participants with income-eligible non-WIC children leads to a conclusion of insufficient evidence. See Appendix D, Evidence Tables D-200 through D-203, D-206, D-212, D-213, D-215, D-217, and D-218 for details.

Child Diet Outcomes in 2009 Food Package Change Studies

One study used the HEI to examine whether diet quality was associated with the 2009 food package change[96], nine examined whether food group intake was associated with the 2009 food package change[57, 69, 83, 86-93, 97], and four examined whether nutrient intakes were associated with the 2009 food package change.[88, 93, 97, 98] Studies that compare outcomes among WIC participants before versus after the 2009 food package change provide indirect evidence regarding the Key Question about the association of outcomes with WIC participation. The findings from these studies are presented in Table 13.

Table 13. Summary of evidence on the association of the 2009 food package change with diet quality outcomes for children

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Diet quality measured by the HEI-2005	• 1 cohort study of African American and Hispanic children ages 2–3.5 years in Chicago, Illinois pre- vs. 18 months post-2009 food package change (154) [96]	• Revised food package associated with a 4-point higher HEI-2005 among Hispanic, but not African American, children, with significant shift from whole milk to low fat milk in both groups.[96]	Inconclusive	Insufficient • Study limitations: Medium • Directness: Indirect • Consistency: Unknown • Precision: Imprecise

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Food group intake	**9 studies;** **7 cross-sectional** • 1 national study [NHANES] of children ages 24–59 months in WIC households 2005–2008 vs. 2011–2014 (1,078)[97] • 1 national cross-sectional study [FITS] of children ages 6–47 months, 2008 vs. 2016 (1,595) [90] • 1 New York State WIC study of children ages 1–4 years, 2009 vs. 2011 (3,562,184)[57] • 1 study of preschool children in WIC households in rural New Mexico, 2008 vs. 2010 (163)[93] • 1 study of children ages 4–24 months in Central Texas, 2009 vs. 2011 (204)[69] • 1 study [NATFAN] of Native American WIC participants ages 2–4 years, 2009 vs 2010-2011 (1,642)[91] • 1 study of predominantly Hispanic children younger than 5 years of age from Los Angeles County, California, 2009 vs. 2010 (6,000)[89] **2 cohort studies** • 1 study of children ages 2–5 years in Atlanta, Georgia, pre vs. 1 week and 4 weeks after receiving revised food package (77)[92] • 1 study of children ages 2–3.5 years in Chicago, Illinois, pre vs. 6 months after receiving revised food package (273)[88]	• In 2 studies revised food package associated with greater intakes of whole grains in children ages 12–24 months.[90, 97] • In 7 studies revised food package associated with greater intake of 1% or non-fat milk and/or decreased intake of whole milk.[57, 88-93] • Revised food package associated with higher fruit and vegetable intakes in 3 studies[90,57, 91], but lower intakes in two studies.[93,69]	The 2009 food package change is likely to be associated with **greater intake of whole grains, and age-appropriate shifts from whole milk to lower fat milk**, which is indirect evidence of a relationship between WIC participation and these outcomes. The 2009 food package change **may be associated with increased intakes of fruits and vegetables (often in the form of baby food)**, which is indirect evidence of a relationship between WIC participation and these outcomes.	Moderate • Study limitations: Medium • Directness: Indirect • Consistency: Consistent • Precision: Precise Low • Study limitations: Medium • Directness: Indirect • Consistency: Inconsistent • Precision: Precise
Nutrient intakes	**4 studies** • 1 national cross-sectional study [NHANES] of children ages 24–59 months in	• Revised food package associated with greater intakes of fiber in 2 studies.[97]	The 2009 food package change may be associated with higher intakes of fiber and lower	Low • Study limitations: Medium • Directness: Indirect • Consistency: Inconsistent • Precision: Precise

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
	WIC households, 2005–2008 vs. 2011–2014 (1,078)[97] • 1 cross-sectional study of preschool children in WIC households in rural New Mexico, 2008 vs. 2010 (163)[93] • 1 cross-sectional study of children ages 4–24 months in Central Texas, 2009 vs. 2011 (204)[98] • 1 cohort study of children ages 2–3.5 years in Chicago, Illinois, pre vs. 6 months after receiving revised food package (273)[88]	• Revised food package associated with a 10% reduction in gram/day intake of saturated fat[93] and with a lower intake of saturated fat (-1.18% of energy) in Hispanic children.[88]	intakes of saturated fat, which is indirect evidence of a relationship between WIC participation and these outcomes.	

HEI = Healthy Eating Index; FITS = Feeding Infants and Toddlers Study; NATFAN = National Food and Nutrition Survey for WIC; NHANES = National Health and Nutrition Examination Survey; vs. = versus; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

[a]Moderate strength indicates that further research may change the result, low strength indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result, and insufficient strength indicates that evidence is unavailable or does not permit a conclusion.

One study reported changes in **diet quality** for WIC children by race/ethnicity, before and 18 months after the 2009 food package change.[96] Post-revision diet quality scores (HEI-2005) were significantly higher for Hispanic children (59.6 vs. 55.6, p=0.02) but not for African American children (53.6 vs. 51.8, p=0.32). These changes in HEI score are of similar magnitude to the differences in HEI score comparing WIC participants with eligible non-participants. However, because there is only one study, the evidence was insufficient for determining whether the 2009 food package change is associated with child diet quality. See Appendix D, Evidence Table D-199 for details.

Nine studies compared **food group intakes** before and after the 2009 food package change, with two national studies, two studies involving one or more states, one large local WIC agency study, and four small local WIC agency studies. Multiple studies reported findings related to whole grains, fruits and vegetables, and milk intakes.

In one national study, significantly more WIC infants 6 to 11 months of age consumed any vegetables (55% vs. 29%) and baby-food fruits (56% vs. 41%) after the 2009 food package change.[90] Similarly, a study[91] of food group intakes of Native American WIC participants 2 to 4 years of age reported a higher percentage of children consuming fruits and vegetables after the 2009 food package change. Post-revision, one study[57] reported that, in New York State, increased percentages of children 1 to 4 years of age consumed fruit (+5.3%), vegetables (+3.5%), and whole grains (+9.1%). However, in rural New Mexico,[93] an 8 percent reduction (95% CI, -15% to 0%) in vegetable intake was reported with no significant differences in fruit, fruit juice, vegetables including potatoes, and whole-grains consumption. In a cross-sectional study of primarily Hispanic WIC infants and toddlers in Central Texas, a study[69] found a lower percentage of toddlers (ages 12 to 24 months) consuming fresh vegetables (15% [post] vs. 23% [pre], p<0.05) and eggs (13% [post] vs. 21% [pre], p<0.05) after the 2009 food package change,

and an increase in zero exposures to fruits or vegetables (31.6% [post] vs. 11.8% [pre], p<0.05) after the 2009 food package change. No significant differences were found in consumption of other foods and beverages, such as jarred meats and infant cereals, between 4 to 6 months of age and 6 to 12 months of age, though sample sizes per age group category were small.

With respect to milk intakes, for children 2 to 4 years of age in New York State WIC, an increased percentage (+4.5%) of participants were reported to consume low-fat or nonfat milk after the 2009 food package change.[57] Another study[89] of data from the Los Angeles County, California WIC program found that the numbers of children younger than 5 years of age who consumed whole milk decreased by 63 percent after the WIC 2009 food package change (p<0.001) with corresponding increases in lower-fat milk (p<0.001). Similarly, a study in Atlanta WIC clinics[92] found that the percentage of children consuming low-fat milk increased from 41.3 percent before receiving the revised food package to 58.8 percent and 79.5 percent at weeks one and four, respectively, after receiving the revised food package (p<0.001). After adjustment, mothers reported increased child consumption of low-fat milk versus whole milk (OR, 7.36; 95% CI, 1.44 to 37.5). In rural New Mexico, a study[93] documented similar trends in preschool-age children from WIC participating households. A higher proportion of children consumed low-fat milk than whole milk (0.81 [post] vs. 0.60 [pre]) after the 2009 food package change compared with before the change and the likelihood of consuming low-fat milk was nearly 3 times higher after the 2009 food package change (OR, 2.94; 95% CI, 1.37 to 6.25). See Appendix D, Evidence Tables D-221, D-227, D-228, D-230 through D-232, D-234, D-237 through D-239, D-241, D-244, D-246, D-249, D-251, D-253, D-254, D-256 through D-258, D-260, D-262, D-264, D-265 for details.

Overall, the findings from the nine studies indicated that the revised food package is likely to be associated with greater consumption of healthier food options among WIC children, with the moderate SOE grade based on indirect evidence, medium study limitations, and overall consistency and precision of the findings. Multiple studies reported greater consumption of whole grains, 100 percent juice, and age-appropriate shifts from whole milk to lower fat milk after the 2009 food package change. Positive patterns were also seen (although not as consistently) to suggest that the revised food package may be associated with greater intakes of fruits and vegetables, most frequently in the form of baby foods.

Some improvements toward meeting the Dietary Reference Intakes for **nutrient intake** were reported in three studies comparing intakes before and after the 2009 food package change. In WIC participants 25 to 59 months of age, a national study[97] reported higher mean intake of fiber (11.6 g vs. 10.6 g; p=0.004), vitamin E (5.3 mg vs. 4.3 mg; p<0.001) and phosphorous (1100 mg vs. 1040 mg; p=0.012) after the 2009 food package change. In contrast, mean intake of zinc was marginally lower after the 2009 food package change (8.1 mg vs. 8.6 mg; p=0.061). In rural New Mexico,[93] a 10 percent reduction in grams of saturated fat (95% CI, -3% to -16%) after the 2009 food package change was found. In a cross-sectional study of primarily Hispanic WIC infants and toddlers conducted in Central Texas[98] the mean intakes of iron, zinc, and vitamins A, D, and E for infants 6 to 11 month of age did not change. However, after the 2009 food package change, lower mean intakes were observed among toddlers 12 to 23 months of age for vitamin A (529 Retinol Activity Equivalents vs. 680 Retinol Activity Equivalents, p=0.05) and zinc (4.8 mg vs. 4.9 mg, p=0.002), whereas higher mean intakes were observed for potassium (p=0.017), vitamin D (p=0.054), and sodium (p= 0.039). After applying a Bonferroni correction, only the change in zinc intake was significant (p<0.006). In a cohort study in Chicago, Illinois, 6 months after receiving the revised food package, Hispanic children had small increases in intake of fiber (+ 1

g/1000kcal, p=0.05) and lower intake of saturated fat (-1.18% of energy, p=0.01).[88] No changes in nutrient intake were found for African American children. See Appendix D, Evidence Tables D-204, D-205, D-207 through D-211, D-214, D-216, D-219 for details.

Overall, we concluded that the 2009 food package change may be associated with better nutrient intakes or adequacy, with low SOE based on indirect evidence, study limitations, reasonable precision of findings, and some inconsistency between studies. Several of the findings were consistent with changes in food group intakes seen in other studies. For example, reduction in saturated fat (reported in 3 of 4 studies) was consistent with transitions to low-fat or no-fat milk, and increased fiber intakes (reported in 2 studies) were consistent with greater vegetable and whole grain consumption.

Dietary Outcomes of Women in WIC Households

Five studies assessed dietary quality and/or intakes of food groups or nutrients among women in households participating in WIC (i.e., primarily caretakers of children participating in WIC). One study examined whether dietary intakes differed by WIC versus eligible non-WIC participation.[99] This study most directly addressed the question regarding WIC participation and dietary outcomes and is presented in Table 14. Four studies examined the impact of the 2009 food package change on dietary intakes among women in WIC households only and represent indirect evidence with respect to the Key Question.[88, 89, 96, 97] Because these studies examined the dietary intakes of women in WIC households rather than WIC participants, they provide evidence of indirect impacts (or spillover effects) of child WIC participation on dietary intakes among women of reproductive age.

Table 14. Summary of evidence on whether dietary outcomes of women in WIC households were associated with WIC participation compared with non-participants eligible for WIC

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Diet quality of caregivers of WIC children measured by HEI-2005	• Secondary analysis of WebNEERS data from Maine (stored EFNEP data), EFNEP vs. WIC vs. WIC and SNAP WIC households (507).[99]	• WIC participation not associated with differences in HEI-2005 scores.[99]	Inconclusive	Insufficient • Study limitations: Low • Directness: Direct • Consistency: Unknown • Precision: Imprecise
Food group intakes (component scores)	• Secondary analysis of WebNEERS data from Maine (stored EFNEP data), EFNEP vs. WIC vs. WIC and SNAP WIC households (507).[99]	• WIC participation not associated with differences in HEI food group component scores.[99]	Inconclusive	Insufficient • Study limitations: Low • Directness: Direct • Consistency: Unknown • Precision: Imprecise
Nutrient intakes (component scores)	• Secondary analysis of WebNEERS data from Maine (stored EFNEP data), EFNEP vs. WIC vs. WIC and SNAP WIC households (507).[99]	• WIC participation not associated with differences in HEI nutrient component scores.[99]	Inconclusive	Insufficient • Study limitations: Low • Directness: Direct • Consistency: Unknown • Precision: Imprecise

EFNEP = Food and Nutrition Education Program; SNAP = Supplemental Nutrition Assistance Program; WebNEERS = Web-Based Nutrition Education Evaluation and Reporting System; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

[a]Insufficient evidence indicates that evidence is unavailable or does not permit a conclusion.

Only one study evaluated diet quality using the HEI to compare WIC households with eligible non-WIC households, all of whom had also participated in the Expanded Food and

Nutrition Education Program (EFNEP) in Maine.[99] The study reported no difference in HEI-2005 scores for WIC households (β, -0.40; p=0.86) versus eligible non-WIC households after EFNEP participation. Further, they found no differences in HEI food group or nutrient component scores. The evidence was insufficient to determine whether living in a WIC household was associated with diet quality or food group and nutrient intakes in women given the imprecise nature of associations and limited number of studies. See Appendix D, Evidence Table D-43 for details.

Dietary Outcomes of Women in 2009 Food Package Change Studies

One study used the HEI to examine whether diet quality was associated with the 2009 food package change[96], and four studies examined whether food group or nutrient intakes were associated with the 2009 food package change.[83, 86-89, 96, 97] Studies that compare outcomes among WIC participants before versus after the 2009 food package change provide indirect evidence regarding the key question about the association of outcomes with WIC participation. The findings from four studies are presented in Table 15.

Table 15. Summary of evidence on the association of the 2009 food package change with dietary outcomes of women in WIC households

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Diet quality of caregivers of WIC children measured by HEI-2005	• 1 cohort study of diet of caregivers of WIC children in Chicago, Illinois, pre vs. 6 and 18 months post 2009 food package change (273)[96]	• Revised food package not associated with significant change in HEI score at 18 months.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Indirect • Consistency: Unknown • Precision: Imprecise
Food group intakes	**4 studies** • 1 cohort study of diet of caregivers of WIC children in Chicago, Illinois, pre vs. 6 and 18 months post 2009 food package change (273)[88 96] • 1 national cross-sectional study [NHANES] of women ages 19–50 years in households receiving WIC benefits, 2005–2008 vs. 2011–2014 (1,078)[97] • 1 cross-sectional study in Los Angeles County, California of pregnant or postpartum and/or caregiver of child enrolled in WIC in 2009 vs. 2010 (6,000)[89]	• Revised food package associated with lower consumption of whole milk and higher consumption of low-fat milk.[88, 89, 96] • Revised food package associated with higher consumption of whole grains,[89] and fruits[88, 89] and vegetables.[89]	The 2009 food package change may be associated with a healthier diet (i.e., greater intake of low-fat milk, whole grains, and fruits and vegetables, and lower consumption of whole milk) in women living in WIC households, which is indirect evidence of a relationship between WIC participation and these outcomes.	Low • Study limitations: Medium • Directness: Indirect • Consistency: Consistent • Precision: Imprecise
Nutrient intakes	**3 Studies** • 1 cohort study of diet	• Revised food package	The 2009 food package change	Low • Study limitations: Medium

Outcome	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
	of caregivers of WIC children in Chicago, Illinois, pre vs. 6 and 18 months post 2009 food package change (273).[88, 96] • 1 national cross-sectional study [NHANES] of women ages 19–50 years in households receiving WIC benefits, 2005–2008 vs. 2011–2014 (1078)[97]	associated with lower intake of saturated fat[88] and higher intake of fiber.[96, 97] • Revised food package associated with higher mean sodium intakes.[97]	may be associated with greater intake of fiber and lower intake of saturated fat in women living in WIC households, which is indirect evidence of a relationship between WIC participation and these outcomes.	• Directness: Indirect • Consistency: Consistent • Precision: Imprecise

NHANES = National Health and Nutrition Examination Survey; vs.=versus; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

[a]Low strength indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result, and insufficient evidence indicates that evidence is unavailable or does not permit a conclusion.

One longitudinal cohort study reported changes in **diet quality of caregivers** for WIC participants before and 18 months after their children received the revised food package.[96] The revised food package was associated with non-significant increases in total HEI score for Hispanic and African American women (1.4% points increase for Hispanic mothers, p=0.62; 5.8% points increase for African American mothers, p=0.13). These changes are in the same range as that reported for women WIC participants; however, the evidence from this single study was insufficient to determine whether the 2009 food package change is associated with diet quality of women living in WIC households. See Appendix D, Evidence Table D-45 for details.

That longitudinal cohort study[96] also reported changes in **intakes of food groups** for caregivers 6 months and 18 months after their children received the revised food package. At 6 months post-revision,[88] changes in milk consumption were reported for Hispanic women with increases in reduced fat milk (0.6 [pre] vs. 0.8 [post], p=0.02) and reductions in mean servings of whole milk observed (0.3 [pre] vs. 0.1 [post], p=0.004). For African American women, only reductions in mean servings of whole milk (0.2 [pre] vs. 0.1 [post], p=0.02) were noted at 6 months post-revision. At 18 months post-revision[96] both Hispanic and African American women were significantly less likely to report consumption of whole milk (32% vs. 5% and 18% vs. 9%, respectively). At 6 months post-revision, increased mean servings per day of fruits (0.8 [pre] vs. 1.1 [post], p=0.04) were reported for Hispanic women, and fewer Hispanic women reported consumption of fruit juice (55% vs. 38%).[88] The other studies reporting differences in food group intakes associated with the 2009 food package change included one national study and one study from Los Angeles County, California WIC. Using NHANES data, one study[97] compared intakes of women 19 to 50 years of age living in households participating in the WIC program. In models adjusted for energy, age, race/ethnicity, poverty income ratio, and household size, mean intakes of women after the 2009 food package change were marginally lower for added sugars ([pre] 21.1 teaspoon-equivalents/day; SE, 0.8; [post] 17.8; SE, 1.6; p=0.068), and higher for whole grains ([pre] 0.62 ounce-equivalents/day; SE, 0.08; [post] 0.89; SE, 0.19; p=0.087). Using data from a cross-sectional survey of pregnant or postpartum women (about 20% of sample) or caregivers of children enrolled in the California WIC program,[89] investigators examined maternal dietary food group intakes before and after the 2009 food package change. In adjusted models, the percentage of women who usually consumed whole-grain foods increased

17.3 percentage points after the 2009 food package change, which was a 51 percent increase (p<0.001). The percentage of women who usually consumed whole milk decreased 15.7 percentage points, which was a 60 percent reduction (p<0.001), with corresponding increases in lower-fat milk consumption (p<0.001). Small but significant increases were observed in family consumption of fruits (increase of 0.1 serving/day, p=0.006) and vegetables (7.2% increase, p<0.001). See Appendix D, Evidence Tables D-79, D-91, D-93, D-97, D-103, D-104, and D-116 for details.

Three studies also reported on **nutrient intakes** and the 2009 food package change. The national study[97] reported higher fiber intakes ([pre] 14.6 g/day; SE, 0.6; [post] 16.4; SE, 0.7; p=0.013) after the 2009 food package change. However, it also reported higher sodium intakes ([pre] 3096 mg/day; SE, 58; [post] 3342; SE, 63; p=0.002). For Hispanic caregivers of WIC children in Chicago, Illinois, small reductions in mean intakes of total fat and saturated fat as percentage of energy were reported at 6 months post-revision (p < 0.05), and in saturated fat as a percentage of energy at 18 months post-revision (p=0.05). [88, 96] See Appendix D, Evidence Tables D-50, D-53, D-59, and D-63 for details of the outcome data.

Studies of the 2009 food package change reporting **dietary intakes of women** in WIC households consistently reported shifts away from whole milk to low-fat or non-fat milk, and when these shifts were reported, lower intakes of saturated fat were also noted. Other changes in food consumption were reported for dietary components directly targeted by the 2009 food package change (e.g., whole grain, fruits, and vegetables) and, consistent with those findings, increased fiber intakes. The studies reporting on intakes of food groups and nutrients had medium limitations but provided relatively consistent findings. Therefore, we consider the SOE to be low for the studies on food groups and nutrient intakes.

Household Purchasing/Benefit Redemption Outcomes

Eleven studies reported associations regarding WIC participation and outcomes of household purchasing or benefit redemption.[21, 100-109] Outcomes across studies varied and included expenditures (in dollars), benefit redemption and non-use, food group and nutrient intakes, purchases of foods and beverages classified as healthy, neutral or moderation, and a household-level HEI. Six studies compared outcomes between WIC households and eligible non-WIC households (Table 16),[100-104, 109] and five studies evaluated purchasing patterns of WIC households before and after the 2009 food package change (Table 17).[21, 105-108] The studies were too heterogeneous to support a meta-analysis. See Appendix D, Evidence Tables D-117 through D-137 for details of the outcome data.

Table 16. Summary of evidence on whether household purchasing outcomes associated with WIC participation compared with non-participants eligible for WIC

Outcomes	Number of Studies and Participants	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Household food purchasing patterns	**6 studies** • 3 studies using national FoodAPS data: WIC vs. eligible non-WIC participating households, comparing weeks with WIC benefits vs. without (out of	• WIC participation associated with 2–3 times higher HEI scores in two studies[102, 103] and, in one study, a 9-point higher score for weeks when WIC benefits were issued.[102]	WIC participation is likely to be associated with household purchasing of food of better diet quality (including increased	Moderate • Study limitations: Medium • Directness: Direct • Consistency: Consistent • Precision: Imprecise

Outcomes	Number of Studies and Participants	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
	pocket) (737)[102]; a matched analysis of WIC vs. non-WIC households (928)[104]; household comparisons of WIC-only, WIC plus SNAP, SNAP only, and eligible non-WIC participant households (1,510)[103] • 2 studies using nationally representative Nielsen Homescan Consumer Panel data, N (unweighted)=584–1,052 households, representing 2,391,230–3,872,730 households in 2008–2010[100]; 5,324 low-income households with children ages 0–4 years in 2008–2014[101] • 1 study using point-of-sale grocery data in Massachusetts and Connecticut, 2009 vs. 2010 (4,440)[109]	• WIC household participation associated with increased monthly purchasing of healthy foods and decreased monthly purchases of moderation foods and beverages. No differences were noted for neutral foods or beverages.[109] • WIC household participation associated with higher scores for total dairy,[104] whole grains,[100-102, 104] seafood/plant protein; and better scores[104] for refined grains[102, 104] and empty calories.[104] • WIC household participation associated with greater scores for total fruit and whole fruit in one study[104] but not in another.[103] • WIC household participation not associated with scores for vegetables or saturated fats.[103] • WIC household participation associated with decreased purchases of refined grains and whole milk.[101]	purchases of whole grains, dairy, fruits, and seafood/plant protein), and reduced purchasing of less healthy foods and beverages (such as refined grains and whole milk).	

FoodAPS = Food Acquisition and Purchase Survey; HEI = Healthy Eating Index; SNAP = Supplemental Nutrition Assistance Program; vs. = versus; WIC= Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Moderate strength indicates that further research may change the result.

Three studies constructed overall measures to assess diet quality based on food purchasing.[102, 103, 109] One study used national Food Acquisition and Purchase Survey (FoodAPS) data from 928 households with at least one person categorically eligible for WIC, evidence of income eligibility, and at least one food-at-home event during the week.[104] They calculated a household-level total HEI score as a measure of healthy purchasing. In a matched sample analysis, WIC participation was associated with a 2.74 (SE, 1.35) higher household HEI total score (p=0.04). When disaggregated into weeks when WIC benefits were issued, a larger difference in HEI-2010 score was estimated (9.44; SE, 1.57); p<0.001), but no difference in score by WIC participation was found when comparing weeks when foods were paid for out of pocket (-0.843; SE, 1.421). One national study used grocery purchase data and compared a household-level HEI-2015 total score among WIC-only households and eligible non-WIC

households with a reference group of WIC-ineligible (i.e., higher income) households.[103] All households had either a woman of reproductive age (14 to 49 years) or a child younger than 5 years old. WIC-only households did not have a statistically significantly difference in total HEI score compared with higher income households (-0.28; 95% CI, -2.51 to 1.95), whereas eligible non-WIC households had a statistically lower HEI, suggesting that WIC-households had higher HEI scores than eligible non-WIC households. Another study of grocery sales data in Massachusetts and Connecticut classified food and beverage purchases as healthy, neutral, or moderation (i.e., less healthy, to be consumed in moderation) and compared purchases between WIC households and former-WIC households before and after the 2009 food package.[109] Mean monthly ounces of total healthy foods purchased were higher (3.9%; 95% CI, 2.1% to 5.7%) among WIC households after the 2009 food package change, but no changes were observed for healthy beverages (-0.03%; 95% CI, -2.9% to 2.5%). Mean monthly ounces of both moderation foods (-1.8%; 95% CI, -0.1% to -3.4%) and beverages including whole milk (-24.7%; 95% CI, -22.6% to -26.7%) were lower for WIC households after the food package change.

Several studies used purchasing data to evaluate food group component scores or food group purchases associated with WIC participation. When considering component scores, WIC households had significantly ($p<0.05$) higher scores for whole grains (1.829; SE, 0.338), total dairy (1.001; SE, 0.415), total fruit (0.798; SE, 0.202), whole fruit (0.534; SE, 0.247), and seafood/plant protein (0.901; SE, 0.261).[104] WIC households also had better (lower consumption) scores for moderation components: refined grains and empty calories.[104] In one study that considered weeks when foods were purchased using WIC benefits,[102] WIC households acquired more whole grains per capita than eligible non-WIC households (1.33 vs. 0.72; $p<0.05$), but not more ounce equivalents of whole grains in cold cereal per capita (0.90 vs. 0.80; $p>0.10$). During weeks when WIC households paid for all food purchases out of pocket, they were 18.7 percent (SE, 5.5%) less likely to purchase at least one whole grain bread, and 19.9 percent (SE, 8.7%) less likely to purchase whole grain cold cereal.

Two studies compared food expenditures and food group and nutrient intakes by WIC participation before and after the 2009 food package change.[100, 101] In one study, the change in whole grain purchases was evaluated using a sample from 2008–2010.[100] Using inverse probability weighting regression adjustment and focusing on households with young children, WIC participation was associated with greater mean monthly whole grain purchases both before and after the revision, with the revised food package associated with a greater mean difference in difference of $1.10 (SE, 0.34) for WIC households. When considering continuous WIC participation over three years (and not just households with young children), participation after the 2009 food package change was associated with a greater mean of $0.77 (SE, 0.27) in whole grain purchases. A second study used this same data source but from 2008–2014, and compared food and beverage groups that the WIC program sought to encourage via the 2009 food package change (e.g., whole vs. refined grains) among WIC participating versus eligible non-WIC participating households with at least one child younger than 5 years of age.[101] Larger but non-significant differences in purchase declines over time were observed comparing WIC households versus non-WIC households for per capita daily calories, sodium, sugar, or total fat. Differences in the declines in purchases of refined grains were observed with greater declines for WIC households (-4.3 g/capita; 95% CI, -6.2 to -2.3). Increases in g/capita purchases of whole grains were observed with greater increases among WIC households soon after the 2009 food package change (1.4; 95% CI, 0.4 to 2.4) but not later (-0.20; 95% CI, -1.3 to 1.0). Declines were also seen in g/capita purchases of whole milk with greater and sustained declines over time among

WIC households in the short term (-11.1; 95% CI, -18.9 to -3.3) and the long term (-15.9; 95% CI, -25.7 to -6.1).

Overall, the studies used different sources of data and considered overall quality of food purchases, as well as purchasing of food groups and nutrients. The results consistently point to better quality of food purchasing for WIC households, greater purchases of healthier food group options (whole grains, seafood/plant protein, total fruit), and fewer purchases of less healthy foods (refined grains and whole milk). Only one study evaluated nutrients (sodium, total fat) and found no differences. Based on the number of studies with medium limitations, consistent findings, and some imprecision in the estimates, we conclude the SOE is moderate that WIC participation was associated with healthier food purchasing at the household level.

Food Purchasing Outcomes in 2009 Food Package Change Studies Among WIC Participants

Studies that compared purchasing outcomes among WIC participants before versus after the 2009 food package change provide indirect evidence regarding the Key Question about the association of outcomes with WIC participation. The findings from five studies are presented in Table 17.

Table 17. Summary of evidence on the association of the 2009 food package change with household purchasing outcomes in WIC participants

Outcomes	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Household food purchasing patterns	**5 studies** • 4 studies used grocery point-of-sale data and compared New England WIC households before (2008) and after (2010) the WIC 2009 food package change (2,137)[106-108], Connecticut WIC households only (515)[105] • 1 state-level study in Wisconsin compared WIC household benefit redemption and purchasing of WIC foods before vs. 6, 12 and 18 months after the 2009 food package change. (243,806)[21]	• Revised food package associated with decreased purchases of whole milk[105] and white bread[108], and increased purchases of whole grain bread and brown rice.[108] For both cheeses[105] and juice,[106] households used non-WIC funds to offset the food package change. Purchases of vegetables and fruits increased overall with households using WIC benefits and fewer non-WIC funds after receiving revised food package.[107] • Revised food package associated with decline in benefit redemption from 74.8% before the 2009 food package change to 70.4% at 18 months after the	The 2009 food package change may be associated with greater purchasing of healthier foods (e.g., whole grains, fruits, and vegetables), and reduced purchasing of less healthy foods and beverages (e.g., refined grains and whole milk), which is indirect evidence of a relationship between WIC participation and these outcomes.	Low • Study limitations: Medium • Directness: Indirect • Consistency: Consistent • Precision: Precise

Outcomes	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
		2009 food package change, and a rise in non-use (0% of benefit used) from 5.5% to 10.3%.[21]		

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Low strength indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result.

Five studies evaluated purchasing patterns before versus after the 2009 food package change in WIC households.[21, 105-108] Four studies used the grocery point-of-sales data scanned from purchases made using a loyalty card from grocery stores in New England (Connecticut and Massachusetts) to evaluate WIC household purchasing patterns before and after the 2009 food package change, with some considering use of WIC benefits as well as non-WIC funds.[105-108] Among 515 Connecticut households, one study evaluated changes in milk and cheese purchases from select groceries.[105] After the 2009 food package change, purchases (expressed as volumes) of total milk, whole milk, and WIC-eligible cheese fell [(-14.2% ($p<0.001$), -50% ($p<0.001$), -37.2% ($p<0.001$), respectively)]. For both milk and cheese, some increase in purchasing using non-WIC funds was also reported, but the amounts of saturated fat from purchased milk and cheese declined by a mean of 85 grams per month per WIC household. Among a larger sample of 2,137 WIC-participating households, one study evaluated pre-post changes in juice and other beverage purchases.[106] After the 2009 food package change, WIC juice purchases were reduced by approximately 71 ounces per month, in line with the juice allowance, and only a 13.6 percent (95% CI, 8.4% to 19.0%) increase in juice purchases was seen using non-WIC funds. Another study reported changes in fruit and vegetable purchases.[107] Purchases of fresh and frozen vegetables increased in volume [(17.5% (12.7% to 22.5%); 27.8% (19.8% to 36.3%), respectively)] with the 2009 food package change; the volume of fresh and total fruit purchases increased 28.5 percent (95% CI, 23.8% to 33.5%) and 25.9 percent (95% CI, 21.5% to 30.6%), respectively, with no changes in canned fruit. The final study of this type reported changes in rice and bread intakes before and after the 2009 food package change.[108] After the 2009 food package change, the share of 100 percent whole grain bread in total bread increased by 312% (95% CI, 285% to 341%) with concurrent reductions in non-100 percent whole grain bread. The share of brown rice in total rice purchases rose by 838 percent (95% CI, 662% to 1060%), while purchases of white rice remained unchanged.

WIC benefit redemption patterns of Wisconsin participants were evaluated one month prior to and then 6, 12 and 18 months after implementation of the 2009 food package change.[21] The percentage of WIC participants who fully used their monthly benefits declined from 74.8 percent at baseline to 70.4 percent at 18 months after the 2009 food package change, with little change in partial use (19.7% and 19.3%, respectively) and a rise in percentage non-use (0% of benefit used) from 5.5 percent to 10.3 percent. There were differences in non-use by race/ethnicity (see Key Question 1b). In adjusted analyses (adjusting for race and ethnicity, food package type, number of benefits issued), a trend for increased non-use after the 2009 food package change was observed at 6 months (OR, 1.34; 95% CI, 1.30 to 1.39), at 12 months (OR, 1.24; 95% CI, 1.20 to 1.28), and at 18 months (OR, 1.71; 95% CI, 1.65 to 1.76).

When examining non-use by WIC participant category, percentage non-use at 18 months after the 2009 food package change was highest, at 20.2 percent, among postpartum women, which represented an 11.4 percent absolute increase ($p<0.0001$). Eighteen months after the 2009

food package change, the percentage of non-use for fully breastfed infants (ages 6 to 11 months) had declined by 18.2 percent, to 19.5 percent. Among children 1 to 4 years of age, the percentage non-use nearly doubled from 5.8 percent to 11.4 percent ($p<0.0001$). Non-use also doubled for partially breastfeeding women and pregnant women.

Overall, use of cash value vouchers for fruits and vegetables was high with a slight decline from 77.8 percent of participants at 6 months to 76.6 percent at 18 months after the 2009 food package change. Nearly all racial and ethnic groups saw an increase in both full (100%) voucher use and non-use (0% of voucher used) regardless of time post-implementation, but with some differences by race/ethnicity. Increases in full voucher use were seen across participant categories; and for children, pregnant women, and postpartum women there were slight increases in percentage non-use ($p<0.001$).

Purchasing data from selected stores in Wisconsin was used to assess the extent to which participants made full benefit redemptions of specific foods, such as beans, peanut butter, milk, whole grains, fruits, and vegetables. The data was also used to evaluate whether households purchased more fruits and vegetables than were provided for through the cash value vouchers. Redemption of most WIC foods did not change from baseline to 18 months after the 2009 food package change. At 18 months after the 2009 food package change, 63.2 percent of WIC households purchased more fruits and vegetables than were provided for by the cash value vouchers, up from 56 percent at 6 months ($p<0.0001$). These increases were observed among Hispanic ($p<0.001$), non-Hispanic White ($p<0.0001$), and non-Hispanic Black households ($p<0.05$), but not among the other groups. Increases were greatest for participants who were children or pregnant women ($p<0.0001$ and $p<0.01$, respectively). See Appendix D, Evidence Tables D-138 through D-142 for details of the outcome data.

Given the medium level of study limitations, the consistency and precision of the findings, and the indirect relation to the Key Question, we conclude that WIC participation after the 2009 food package change may be associated with greater purchasing of healthier foods and reduced purchasing of less healthy foods. Only one study used WIC benefit redemption data and examined whether WIC households made full, partial, or zero percent use of their benefits when purchasing foods or using their cash value vouchers for fruits and vegetables. The analysis was limited in that it presented an unadjusted description of food benefit redemption patterns over time by food package type and by race/ethnicity. Thus, no conclusions are drawn regarding the 2009 food package change and benefit redemption.

Findings from Qualitative Studies About Child Dietary Outcomes

Five qualitative studies sought to understand **purchasing practices** and **benefit redemption** related to child WIC participation and eligibility. [21,110-113] .One study used a think-aloud methodology (verbalization with task performance at grocery stores) to capture real time decision making among 28 parents of preschool-aged children participating in Delaware WIC [110]. Study found that WIC eligible food items drove shopping patterns, and in some cases changed feeding practices. For example one parent stated that "… *it's 1% milk with the WIC. When I didn't get WIC, I was drinking 2% and giving them [the children] 2%.*" Similarly, focus group participants attending Wisconsin WIC after the 2009 food package change reported liking some but not all of the changes. For example, participants stated that they liked the addition of beans (as a possible replacement for peanut butter) and had no problem buying whole wheat bread or tortillas. However, despite using their WIC benefits to purchase it, many reported

dissatisfaction with the change to lower fat milk, thinking it was less healthy for their children.[21] Another study in Phoenix, AZ [111] conducted eight focus groups to explore perceived barriers related to addition of the WIC fruit and vegetable benefit. Participants (N=41) included caregivers who were primarily responsible for buying and preparing food for their households. Caregivers reported multiple barriers at the store, including negative interactions with staff and confusion over WIC food purchasing rules (e.g., what fruits and vegetable were allowed vs. not). Among experienced WIC shoppers, strategies emerged to deal with these barriers and maximize the value of their fruit and vegetable benefits, including use of reward points and strategic choice of shopping times and locations. Findings from in-depth interviews [112] conducted with caregivers of infants enrolled in WIC across eight clinics in Illinois found that caregivers valued the infant food package over other WIC food packages but noted that the addition of the fruit and vegetable cash voucher increased the value of many of the packages. Finally, a study [113] of Latino caregivers recruited from a community health center in Northern California used semi-structured interviews (N=29) to understand beliefs related to beverages consumption among infants and toddlers. Some caregivers reported that mixed messages from WIC led to confusion; for example, parents were told to avoid fruit juice, but then it was given to them by WIC, or included on the list of WIC eligible items. See Appendix D, Evidence Table D-143 for details.

Child Development and Academic Achievement Outcomes

Five studies overall (two cohort studies, two cross-sectional studies, and one study which employed cohort and cross-sectional analyses) reported on the association of WIC participation with the outcomes of child development or academic achievement.[44, 61, 62, 114, 115] The summary of findings and SOE for the outcomes are presented in Table 18. The studies were too heterogeneous (in terms of study design, study population, and outcome measures) to support a meta-analysis. See Appendix D, Evidence Tables D-279 through D-284 for details.

Table 18. Summary of evidence on whether infant and child development outcomes were associated with WIC participation compared with non-participants eligible for WIC

Outcomes	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Cognitive development	• 1 cross-sectional study of preterm children up to 24 months corrected age (71)[62]	• Child WIC and WIC plus SNAP participants up to 24 months of age had higher adjusted mean cognitive development scores than non-participants.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Imprecise
Cognitive development	**2 cohort studies** • 1 difference-in-differences analysis of cohort study comparing data from 2006–2011 of maternal-child dyads; outcomes measured at ages 12, 24 months and ages 4–6 years (1,222)[61]	• Maternal WIC participation was associated with greater cognitive development scores on Bayley Scales of Infant Development. No significant difference was found in Stanford-Binet Intelligence Scale scores in the children at ages 4–6 years.[61] • In a matched pairs analysis, maternal WIC participation was associated with higher cognitive development z-scores on Bayley Scales of	Maternal WIC participation may be associated with higher cognitive development scores in early childhood.	Low • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise

Outcomes	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
	• 1 national birth cohort study of children (6,120)[115]	Infant Development mental development scores at age 2 years.[115]		
Social development	• 1 cohort study of children ages 12–24 months (372)[114]	• Using a within-child fixed effects analysis, child WIC participation was not associated with changes in social development measures (subdomains of the Brief Infant Toddler Social Emotional Assessment scales) at ages 12 and 24 months.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise
Social development	• 1 difference-in differences analysis of cohort study comparing data from 2006–2011 of maternal-child dyads; outcomes measured at ages 12 and 24 months (1,222)[61]	• Maternal WIC participation was not associated with significant differences in social development scores on the Brief Infant Toddler Social Emotional Assessment Problem and Competency scale at ages 12 and 24 months.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise
Motor development	• 1 cross-sectional study of preterm children up to 24 months corrected age (71)[62]	• Child WIC and WIC plus SNAP participants up to age 24 months had mean scores on motor development measures that were similar to non-participants.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Imprecise
Communication and adaptive behavior	• 1 cross-sectional study of preterm children up to 24 months corrected age (71)[62]	• Child WIC and WIC plus SNAP participants had significantly higher adjusted mean scores on measures of communication and adaptive behavior at age 24 months.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Imprecise
Communication and adaptive behavior	• 1 difference-in-differences analysis of data from a cohort study comparing data from 2006–2011 of maternal-child dyads; outcomes measured at ages 12 and 24 months (1,222)[61]	• Maternal WIC participation was not associated with significant differences in measures of communication at 12 and 24 months.	Inconclusive	Insufficient • Study limitations: Medium • Directness: Direct • Consistency: Unknown • Precision: Precise
Developmental risk	• 1 cross-sectional study of children ages 4–36 months (12,624)[44]	• Child WIC participation did not attenuate the association between stressors (household food insecurity and maternal depressive symptoms) and childhood developmental risk.	Inconclusive	Insufficient • Study limitations: High • Directness: Indirect** • Consistency: Unknown • Precision: Precise

Outcomes	Number of Studies and Participants (N)	Study Results	Conclusion	Strength of Evidence (Rationale)[a]
Academic achievement	• 1 cross-sectional study (263 sibling pairs)[115]	• Comparing outcomes of siblings with discordant maternal WIC participation, children of mothers exposed to WIC had higher reading (broad reading and passage comprehension) scores at age 11 years and higher math achievement scores, though the differences were not significant.	Inconclusive	Insufficient • Study limitations: High • Directness: Direct • Consistency: Unknown • Precision: Precise

SNAP = Supplemental Nutrition Assistance Program; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children

[a]Low SOE indicates low confidence that the evidence reflects the true effect, and further research is very likely to change the result and insufficient SOE indicates that evidence is unavailable or does not permit a conclusion.

Child Development: Cognitive, Social, Motor, Communication and Adaptive Behavior, Development Risk

Three studies reported on the association between WIC participation and **cognitive development**[61, 62, 115], two studies examined maternal WIC participation,[61, 115] and one study examined child WIC participation.[62] One study examining maternal WIC participation used data from the CANDLE longitudinal cohort study based in Tennessee (which enrolled 1,503 pregnant women from 2006–2011); specifically, this study examined 1,222 maternal-child dyads and employed a difference-in-differences analysis to examine how maternal receipt of the revised food package was associated with various developmental outcomes inclusive of cognitive development, compared with WIC-eligible non-participation.[61] This study found an association between maternal receipt of the revised WIC food package and cognitive development (Bayley Scales of Infant Development Cognitive composite score at 24 months of age; β coefficient for the interaction between WIC participation and post-food package change for cognitive composite score: 4.34; 95% CI, 1.11 to 7.57, indicating a greater score after the 2009 food package change for children of mothers who participated in WIC compared with children whose mothers did not participate in WIC). If we consider a standard deviation in the score of 15, this represents a difference which is meaningful at the population level. However, no difference was seen on measures of cognitive development at 4 to 6 years of age (Stanford-Binet Intelligence Scales; β coefficient for interaction -0.07; 95% CI, -3.59 to 3.45). A second study used data from the Early Childhood Longitudinal Study and compared child cognitive development by maternal WIC participation after matching on socioeconomic characteristics, maternal education and smoking, and reading to the child.[115] Maternal WIC participation was associated with statistically significantly stronger cognitive development measures at 2 years of age (Bayley mental development z-scores; β, 0.0625; SE, 0.03; $p<0.05$). We concluded that **maternal WIC participation** may be associated with improved **child cognitive development outcomes**, with low SOE taking into consideration the limitations of the two available studies.

The association between child WIC participation and **cognitive development** was examined in one cross-sectional study which assessed 71 preterm infants (gestational age less than 37 weeks) up to 24 months of age from a high-risk infant clinic (2013–2015).[62] The study found that mean adjusted cognitive development scores were significantly higher for child WIC participants than non-WIC children and higher for child participants in WIC and SNAP than children not

enrolled in both programs (Bayley Scales of Infant and Toddler Development, third edition, scores; β, 11.7, 95% CI, 1.2-22.2, for WIC participants; β, 11.5, 95% CI 0.1 to 22.9, for WIC and SNAP participants). Despite these large and potentially clinically important differences, the SOE was insufficient to determine whether child WIC participation was associated with cognitive development outcomes. There was only one available study which evaluated the association in a specific, high-risk population subset (preterm infants).

Two studies examined **social development outcomes** in children, one examining maternal WIC participation[61] and one examining child WIC participation.[114] The study that examined maternal WIC participation[61] used difference-in-differences analysis to examine the interaction between maternal receipt of the revised food package and various development measures, including social development. No differences were found by maternal WIC participation in child social development scores at 12 and 24 months of age (Brief Infant Toddler Social Emotional Assessment [BITSEA] Problem and Competency subdomain scores: β coefficient for the interaction: -0.46; 95% CI, -1.85 to 0.94; at 24 months: 0.49; 95% CI, -2.11 to 1.12; and for competency scores at 24 months: -0.12; 95% CI, -0.80 to 0.57). In the cohort study that examined the association of child WIC participation with social development,[114] employing within-child fixed effects analyses, BITSEA scores among 372 children at 12 and 24 months of age were not significantly different by child WIC participation status (BITSEA Competence subdomain coefficient 0.22; SD, 0.39; BITSEA Problem subdomain coefficient -0.58; SD, 0.79). Further, no significant association was seen in a subgroup of children who had been exposed to WIC prenatally (Competence subdomain coefficient 0.27, SD 0.40; Problem subdomain coefficient -0.60, SD 0.83). The SOE was insufficient to support a firm conclusion about whether either maternal or child WIC participation was associated with **child social development** measures because of the paucity of studies and study limitations.

Child communication and adaptive behavior were examined in two studies, one that reported on the association with maternal WIC participation[61] and one that examined the association with child WIC participation.[62] In the study using difference-in-differences analysis[61], no significant interaction was found between maternal WIC participation and measures of child communication at 24 months of age (Bayley Scales of Infant Development; β coefficient for the interaction for Receptive Communication subtest: -0.21, 95% CI, -0.91 to 0.49; for Total Language subtest: -0.39; 95% CI, -4.13 to 3.35). The association of child WIC participation and adaptive behavior was examined in a cross-sectional study of 71 preterm infants[62], which found that the mean adjusted measure of adaptive behavior in children up to 24 months of age was significantly higher for WIC children than non-WIC children and higher for participants in WIC and SNAP than children not in both programs (Vineland Adaptive Behavior Scales, second edition, scores: β, 10.1, 95% CI, 1.9 to 19.1, for WIC participants; β, 10.3, 95% CI, 0.9 to 19.7, for WIC and SNAP participants). If we consider an SD of 15 for the Vineland scale, these are large differences and likely clinically relevant. However, owing to the paucity of studies and study limitations, we concluded that the SOE was insufficient to support a conclusion about whether maternal or child WIC participation was associated with **child communication or adaptive behavior.**

The study among preterm infants[62] also examined **motor development** measures in children up to 24 months of age, using the Bayley Scales' Composite Motor Score. No significant differences were noted between children participating in WIC versus those not participating in WIC or children participating in WIC and SNAP versus those not participating in both programs. The SOE was insufficient to support a conclusion about child WIC participation and **motor**

development outcomes because there was only one study whose limitations included being limited to analysis of a high-risk subset of children.

One cross-sectional study examined whether child WIC participation attenuated the adverse impact of stressors (household food insecurity and maternal depressive symptoms) on **child developmental risk** using Children's Health Watch Data from 2000–2010 for 29,650 children 4 to 36 months of age.[44] Developmental risk was defined as one or more caregiver-reported developmental concerns on the Parents Evaluation of Developmental Status questionnaire. Child WIC participation did not attenuate the association between number of stressors and developmental risk (for 2 vs. 0 or 1 stressor: WIC participant adjusted OR, 2.12, 95% CI, 1.79 to 2.51; WIC non-participant adjusted OR, 2.03, 95% CI, 1.32 to 2.11). The SOE was insufficient to evaluate the association of WIC participation with **developmental risk** given the only available study's limitations, which included indirect examination of this association. See Appendix D, Evidence Tables D-279 through D-283 for details on the developmental outcomes.

Academic Achievement

One study evaluated academic achievement measures associated with WIC participation.[115] This study used Child Development Supplement data from the Panel Study of Income Dynamics (2007) to compare academic achievement among 263 children exposed to WIC in utero (maternal WIC receipt) with their WIC-unexposed siblings.[115] Woodcock-Johnson revised reading and math achievement test scores at 11 years of age were analyzed. Children exposed to WIC in utero had higher broad reading scores within family fixed effects (broad reading z-score coefficient 0.256; SD, 0.11; $p< 0.05$), and higher passage comprehension (letter-word identification fixed effects coefficient 0.256; SD 0.12, $p<0.05$) than their WIC-unexposed siblings. WIC exposure was also associated with higher math achievement z-score, though the difference was not statistically significant (within-family fixed effects applied problems z-score coefficient 0.091, SD 0.12; between-family ordinary least squares coefficient 0.029, SD 0.11). Overall, measures of academic achievement (reading and math achievement scores at 11 years of age) were higher among children exposed to WIC in utero than among children who were not. The SOE was insufficient for this outcome because there was only one study, which had high limitations. See Appendix D, Evidence Table D-284 for details.

Findings from Qualitative Studies About Child Development and Academic achievement

No qualitative studies addressed the association of WIC with child development and academic achievement.

Key Question 2a. Does the association of infant and child outcomes with WIC vary by age at WIC or duration of WIC participation?

Key Points

- Duration of WIC participation may be positively associated with child diet quality (SOE: Low).
- The evidence was insufficient to determine whether age at WIC or the duration of WIC participation was associated with child health outcomes, infant or child mortality, anemia, child overweight and obesity, recovery from malnutrition, breastfeeding, or child development owing to the paucity of studies examining this question (SOE: Insufficient).

Infant and Child Health Outcomes

No studies addressed the association of infant and child health outcomes by age at WIC or duration of WIC participation, with the exception of one study regarding recovery from anemia.

Recovery From Anemia

One small prospective cohort study reported on the association of WIC participation with anemia.[48] This prospective cohort study examined the correlation between number of WIC visits and recovery from anemia (based upon measurement at the last WIC visit), using Massachusetts WIC program data from 1998–2010. Among 191 refugee children younger than 5 years of age who were diagnosed with anemia at their first WIC visit, a higher number of WIC visits (categorized as 5 or more vs. 2–4) was significantly associated with increased odds of recovery from anemia (adjusted OR, 6.50; 95% CI, 2.69 to 15.69), after adjusting for caregiver sociodemographic characteristics and child age, breastfeeding history, and birth weight. Because there was only one single-site study, which was further limited to a population of refugees, the evidence was insufficient to determine whether WIC participation was associated with anemia.

Child Anthropometric Status

Studies explored whether the association of WIC participation and multiple child anthropometric outcomes varied by child age at WIC or duration of WIC participation. Studies evaluated child high weight status, including overweight and obesity; growth velocity; and recovery from malnutrition (low weight or length status).

Child High Weight Status

Two studies directly assessed the association of duration of participation with high weight status,[22, 23] and three other studies provide indirect evidence as to whether the association between WIC participation and child high weight status, overweight, or obesity varied by age or duration of WIC participation.[50, 54, 57]

The most direct evidence comes from the results reported from the WIC Infant and Toddler Feeding Practices Study 2 (ITFPS-2)[22, 23] No difference in risk of overweight or obesity (differences in BMIz) among WIC participants at 3 or 4 years of age were found compared with those who participated until 2 or 3 years of age, respectively.

Results from WIC trend studies provide indirect evidence for the association between duration of WIC participation and child high weight status. These studies showed consistent declines in prevalence of overweight and obesity by age. In a study that examined trends in prevalence of overweight and obesity among WIC participating children 2 through 4 years of age from 50 states, the District of Columbia, and five U.S. territories from 2010–2016[50], the adjusted prevalence of overweight/obesity and obesity decreased in the overall sample and among children 2, 3 and 4 years of age, respectively (adjusted prevalence difference of overweight/obesity among children 2 years of age: -3.0; 95% CI, -3.1 to -2.9; among children 3 years of age: -3.5; 95% CI, -3.6 to -3.4; among children 4 years of age: -3.3; 95% CI, -3.5 to -3.2). A cross-sectional study using New York State WIC program data that examined the impact of the food package change on overweight and obesity prevalence in children 1 to 4 years of age found a decline in the prevalence of obesity (2 through 4 years of age) or high WHZ (1 to 2 years of age) among children throughout this age range in the period after the food package change.[57]

Two studies that compared duration of exposure to the revised versus the pre-2009 food package also indirectly addressed the question about the effect of age at WIC participation. One study examined duration of revised versus pre-2009 food package exposure, characterized by age at receipt of the food package and the association with child overweight and obesity.[54] This longitudinal study of WIC participants in Los Angeles County, California examined obesity prevalence at 4 years of age, using matched samples of children who received a "full" dose (exposure to the food package from 0 through 4 years of age) or "late" dose (exposure to the food package from 2 through 4 years of age). Among boys, full or late exposure to the revised food package was associated with lower obesity risk at 4 years of age; but, among girls, obesity risk was lower only among those receiving a full dose of the revised food package.[54]

The SOE was insufficient to determine whether increased duration of WIC participation was associated with differences in child overweight or obesity owing to a limited number of studies, some of which provided indirect evidence only, and varying definitions of duration used.

Growth Velocity

No studies directly evaluated the association between duration of WIC participation and child growth velocity. Five studies provided indirect evidence, as they examined variations in WLZ or WHZ trajectories over age intervals or considered duration of exposure to types of WIC food packages.[52-55, 60]

Three studies were longitudinal studies of WIC-participating children in Los Angeles County, California.[52, 54, 55] One study examined growth velocities over 6-month or 12-month periods to understand differences in obesity outcomes at 4 years of age associated with receipt of the revised versus the pre-2009 WIC food package.[54] Growth velocities did not differ during the first 6 months, but among both boys and girls, a slower velocity was found among those receiving the revised food package from 6 to 12 months of age; velocities after 1 year of age did not differ significantly. Among those who received the revised versus the pre-2009 food package from 2 through 4 years of age, differences in WHZ or BMIZ velocities were only seen among boys at from 3 to 4 years of age, with slower growth velocities associated with receipt of the revised food package.

Another study compared growth patterns over time by the duration of receipt of the fully breastfeeding package,[55] which was associated with differences in growth velocities over time. The association varied by age interval. With longer exposures, faster growth velocities were seen

from 0 to 6 months of age, but slower velocities were seen at 6 to 12 months of age, and lower mean WLZ at 1 to 2 years of age.

In a study that explored growth velocity differences by type of infant food package and revised versus pre-2009 food package,[53] WLZ velocities were slower from 6 to 12 months of age for infants receiving the revised mostly breastfed, mostly formula fed, or fully formula fed groups. No differences over age intervals were found in the fully formula fed subgroup.

A related study that followed up on infants receiving the fully formula feeding package[52] also examined the association between duration of receipt of the revised food package on WLZ or WHZ trajectories and mean WLZ or WHZ differences across age intervals. It found small and largely non-significant differences in both the trajectory and mean WHZ across certain age intervals and by duration of receipt of the revised food package.

In analyses that evaluated the modifying effect of initial WLZ status on the association of exposure to the revised or pre-2009 food package, outcomes were assessed across yearly intervals.[60] One difference noted by child age was among children in the high WLZ stratum, where mean WLZ was lower for boys receiving the revised versus pre-2009 food package across ages 1 to 5 years; but, among girls, the mean WLZ was lower only at 1 year of age.

Taken together, these results provide some indication of differential WLZ responses to the revised food package in late infancy, which is indirect evidence that growth velocity outcomes vary by age at WIC enrollment and the potential importance of WIC participation during infancy. However, these associations vary by type of revised food package, which is related to caregiver breastfeeding decisionmaking and not the program. Without comparative data from WIC-eligible non-participants, no conclusion can be drawn. Therefore, the evidence was insufficient as to whether the association of WIC participation with growth velocity varies by age at enrollment or duration of participation.

Recovery from Malnutrition

One small study evaluated associations of WIC participation with anthropometric outcomes among refugee children in Massachusetts from 1998–2010.[48] Of those who entered the program with low WAZ (less than -2), the study reported no significant association between number of WIC visits and recovery (WAZ greater than or equal to -2), with adjusted OR for at least five visits versus two to four visits of 1.73 (95% CI, 0.31 to 9.76). For those who entered with stunting (height-for-age z-score less than -2) and who had five or more WIC visits, there were significantly higher odds of recovery from stunting (height-for-age z-score greater than or equal to -2) compared with children with two to four total WIC visits (adjusted OR, 12.1; 95% CI, 2.82 to 52). The SOE was insufficient to determine whether duration of WIC participation was associated with recovery from malnutrition.

Breastfeeding

No studies assessed association of duration of WIC participation and breastfeeding.

Child Dietary Outcomes

Three studies used the longitudinal data from the WIC ITFPS-2 study to assess whether diet quality differed by duration of WIC participation.[22, 94, 95] In two reports, duration of WIC participation was categorized as high, medium, or low based on the number of times participants reported receiving WIC benefits; and, in one study,[22] six different participation patterns were identified. In adjusted analyses at 24 months of age, children in the high duration group had

better overall diet quality (HEI-2015, 59.3 vs. 55.3, $p<0.05$) than children in the low duration group, corresponding with greater intakes of vegetables ($p=0.007$), greens and beans ($p=0.0002$), seafood and plant protein ($p=0.005$), refined grains ($p=0.024$), and saturated fat ($p=0.012$).[95] At 3 and 4 years of age, those who were still participating in WIC were more likely to meet the added sugars moderation component of the HEI.[22] Despite the consistency of the findings and the medium limitations of the studies, because the three studies are reports from the same data source, we conclude that the SOE was low that duration of WIC participation was positively associated with diet quality.

Child Development and Academic Achievement

No studies addressed the association of child development or academic achievement by age at WIC or duration of WIC participation.

Key Question 2b. Does the association of infant and child outcomes with WIC vary by participant factors such as age of the mother at delivery, race/ethnicity of mother, geographic location (e.g., region, urban vs. rural), education of the mother, employment status of the mother, marital status, or housing (e.g., public, homeless)?

Key points

- Despite some specific studies evaluating differential association of outcomes with WIC participation by racial and ethnic groups, the evidence was insufficient to draw conclusions on this question (SOE: Insufficient).
- No studies were identified that considered other participant characteristics.

Infant and Child Health Outcomes

No studies addressed whether there is a differential association of infant and child health outcomes by WIC participant characteristics, with the exception of one study regarding maternal WIC participation and infant mortality by maternal race and ethnic groups.

Infant and Child Mortality

One study assessed the association of infant mortality with WIC participation stratified by race and/or ethnicity.[26] This national cohort study used birth certificate data and showed that the difference between WIC participation and non-participation in infant mortality was consistent among different subgroups by race and ethnicity (non-Hispanic White: adjusted OR, 0.90; 95% CI, 0.87 to 0.93, non-Hispanic Black: adjusted OR, 0.91; 95% CI, 0.87 to 0.95, and Hispanic: adjusted OR, 0.85; 95% CI, 0.81 to 0.90).[26] The evidence from this single study suggests no difference by race or ethnicity in the association of WIC participation with infant mortality reduction. However, the evidence from this single study was insufficient to support a conclusion for this outcome.

Child Anthropometric Status

No studies addressed whether there is a differential association of child anthropometric status outcomes by WIC participant characteristics, with the exception of two studies which indirectly assessed whether the association between exposure to the revised food package and high weight status varied by race and ethnic groups.

High Weight Status

No studies directly assessed whether WIC participation was differentially associated with high weight status, overweight, or obesity by race or ethnicity.

Two studies examined the association of overweight and obesity with WIC participation by race and ethnic groups.[50, 57] In a study that examined trends in prevalence of overweight and obesity among WIC-participating children 2 to 4 years of age from 50 states, the District of Columbia, and five U.S. territories from 2010–2016[50], the prevalence of overweight/obesity and obesity decreased in the overall sample and in racial and ethnic subgroups (adjusted prevalence difference of overweight/obesity: non-Hispanic White: -0.7; 95% CI, -0.8 to -0.6; non-Hispanic Black: -1.2; 95% CI, -1.3 to -1.1; Hispanic: -2.8; 95% CI, -2.9 to -2.7; American/Indian/Alaska Native: -2.4; 95% CI, -3.0 to -1.9; Asian/Pacific Islander: -2.4; 95% CI, -2.6 to -2.2).

A cross-sectional study of New York State WIC program data from 2008–2011 examined the association between the 2009 food package change and overweight and obesity prevalence among 260,935 WIC-participating children 2 through 4 years of age. The study demonstrated an overall decline in prevalence of overweight (-3.0%) and obesity (-2.7%) over the time period.[57] The decline was observed among racial and ethnic subgroups, with the largest relative percent decrease among Black children (4.5%), and the smallest relative percent decrease among Hispanic children (1.6%). The relative percent decrease was 3.8 percent in White children and 3.3 percent in Asian children. These studies suggest that the association between exposure to the revised food package and lower prevalence of overweight and obesity is consistent across the racial and ethnic groups studied. However, the evidence was insufficient to draw a conclusion because the only two available studies provided only indirect evidence about the question.

Breastfeeding

One study in South Carolina (2004–2013) examined WIC participation and breastfeeding initiation and presented results stratified by maternal race.[24] Among Black women, WIC participation was associated with a 2.76 percent (SE, 0.57%) higher rate of breastfeeding initiation, whereas in White women no significant difference in initiation by WIC participation was found (1.2% [SE, 0.56%]). When considering all South Carolina births during the time period, and adjusting for maternal and child characteristics, year of birth, and multiple pregnancies with women over time (but not income or Medicaid use), WIC participation was associated with a statistically significant 2.54 percent (SE, 0.46) higher rate of breastfeeding initiation for Black women and no difference in breastfeeding initiation (-0.45, SE, 0.34) among White women.

Several studies evaluated associations between exposure to the revised food package and breastfeeding outcomes by racial and ethnic groups. A prospective cohort study using New York Pediatric Nutrition Surveillance System (PedNSS) reports from 2002–2015 assessed temporal trends in breastfeeding initiation and duration of more than 1 month.[67] Breastfeeding initiation increased significantly, from 62.0 percent in 2002 to 83.4 percent in 2015, with an annual percent change of 2.4, or an average of 1.7 percentage points, per year. Stratifying by maternal

race and ethnicity, the study reported the largest increase in breastfeeding initiation for Asian infants, from 45.8 percent in 2002 to 84.7 percent in 2015. It was reported that the racial/ethnic disparity in breastfeeding initiation rate (i.e., the difference between the highest and the lowest rates among White, Black, Hispanic and Asian infants in a particular year) was reduced from 26.5 percentage points in 2002 (Hispanic vs. Asian) to 9.2 in 2015 (Hispanic vs. White). In addition, all breastfeeding duration trends by race/ethnicity demonstrated significant improvements for breastfeeding duration of 1 month or more, with the largest increase occurring among Asians. Because the evidence suggested no difference in breastfeeding initiation with exposure to the revised food package, the revised food package may have differentially benefited breastfeeding outcomes for specific race groups.

The findings across multiple studies of predominantly Hispanic women in Los Angeles County, California suggested positive findings for the association between the 2009 food package change and breastfeeding initiation and exclusivity.

The one study with direct evidence and the multiple studies with indirect evidence suggested that WIC participation may be associated with differential improvement over time in breastfeeding outcomes by maternal racial and ethnic groups. However, the evidence was insufficient to draw conclusions with respect to these outcomes because of the limitations of the studies and the indirect nature of most of the evidence.

Child Dietary Outcomes

No studies evaluated WIC participation and dietary outcomes by race or ethnic groups. However, four studies evaluated the association indirectly by evaluating exposure to the revised versus the pre-2009 food package within specific race or ethnic groups.[88, 89, 91, 96] In one study that evaluated the dietary outcomes after 6 and 18 months of exposure to the revised food package, Hispanic children consumed more whole grains at 6 months after receiving the revised food package, and both Hispanic and African American children consumed more low-fat milk with corresponding reductions in whole milk across both time points ($p<0.05$). In addition, 18 months after receiving the revised food package, Hispanic children tended toward consuming more vegetables than prior to the 2009 food package change, but the difference was not statistically significant ($p=0.08$). Concurrently, African American children consumed more sugar-sweetened beverage after receiving the revised food package ($p=0.02$). Nutrient intakes were also assessed, with Hispanic children consuming a smaller percentage of energy from saturated fat (but not total fat) at 6 months after receiving the revised food package (-1.18%, $p=0.01$) and both less saturated and total fat at 18 months after receiving the revised food package compared with the pre-2009 food package (-15%, $p=0.0004$; 10.5%, $p<0.05$, respectively). Among Hispanic children, fiber intakes (g/1000 kcal) were higher at both 6 months and 18 months after receiving the revised food package compared with the pre-2009 food package ($p=0.03$), but no differences were observed among African American children. One study provided findings on differences, after the 2009 food package change, in the food group intakes of Native American WIC participants 2 to 4 years of age.[91] With the revised food package, greater proportions of children were consuming fruits and vegetables, and the frequency of consumption of white bread decreased, while the frequency of consumption of wheat bread increased. Children 3 years of age showed a decrease in consumption of whole milk and an increase in consumption of low-fat milk. Finally, the numbers of predominantly Hispanic children in the Los Angeles County, California WIC program who consumed whole milk

decreased by 63 percent after the 2009 food package change ($p<0.001$) with corresponding increases in consumption of lower-fat milk ($p<0.001$).[89]

The evidence was insufficient to draw conclusions about whether the association of WIC participation with dietary outcomes varies by race and ethnic groups owing to the indirect nature of the evidence and medium study limitations. However, studies of WIC-participating children in selected populations provided some evidence that the 2009 food package change was associated with changes in food group intakes consistent with better diet quality for Hispanic and Native American children.

Child Development and Academic Achievement

One study examined the association of child development outcomes with WIC participation by race. In the study, which examined the impact of child WIC participation on social development from 12 to 24 months of age,[114] no differences were seen by child WIC participation in the overall sample, and subgroup analyses among only African American children revealed no significant effect of WIC participation on BITSEA scores (competence subdomain coefficient 0.43; SD 0.42; problem subdomain coefficient -0.18; SD 0.80). The evidence from this study was insufficient to support a conclusion because of medium limitations.

Discussion

Findings in Relation to the Decisional Dilemmas

This systematic review synthesized recent evidence regarding the effectiveness of WIC that is pertinent to decision making at the clinical, programmatic and policy levels. Many people need reliable information about the effectiveness of WIC, including health care practitioners, public health professionals, researchers, and policy makers as well as WIC participants, staff, and leadership. Policy makers at the local, state, and federal levels need such information to determine whether changes should be made in WIC programming to further improve outcomes for women and children. Key Question 1 focused on the association between maternal participation in the WIC program and maternal, neonatal, and infant birth outcomes. Key Question 2 focused on the association of WIC participation with infant and childhood health and developmental outcomes. Overall, we found 93 studies that fit our inclusion criteria, of which 77 were quantitative observational studies and 16 were qualitative studies. A summary of the direct evidence regarding WIC participation and maternal and child outcomes is provided in Table 19.

Table 19. Summary of the direct evidence regarding association between WIC participation and outcomes

Outcomes	Evidence on association between WIC participation and outcomes	Insufficient evidence despite one or more studies
Maternal health outcomes (KQ1)		• Gestational weight gain (1 study)
Neonatal and infant birth outcomes (KQ1)	**May be associated (Low SOE)** • Less preterm birth (3 studies) • Less infant low birth weight (3 studies)	• Fetal death, stillbirth and neonatal mortality (1 study) • NICU admission and hospital length of stay (1 study)
Maternal dietary outcomes (KQ1)		• Diet quality of pregnant/ postpartum WIC participants (1 study) • Food group and nutrient intakes of pregnant/ postpartum WIC participants (1 study)
Infant and child health outcomes (KQ2)	**May be associated (Low SOE)** • Lower infant mortality (2 studies)	• Morbidity -health status, hospitalization (1 study) • Health care utilization -preventive care visits (1 study) • Health care utilization- immunizations (maternal WIC 1 study) (child WIC 2 studies)
Child growth anthropometric status (KQ2)		• Child weight status, overweight and obesity (1 study) • Z-scores of length, height, weight or weight-for-length/height -maternal(1 study), child (1 study)
Breastfeeding outcomes (KQ1 & KQ2)	**May <u>not</u> be associated (Low SOE)** • Breastfeeding initiation (4 studies)	• Breastfeeding duration (2 studies) • Breastfeeding exclusivity (1 study) • Introduction of solids before 4 months (1 study)
Child dietary outcomes (KQ2)	**Likely to be associated (Moderate SOE)** • Child higher diet quality (2 studies) • Child higher healthy food group intake (3 studies) • Household purchasing of healthy food groups (6 studies)	• Child nutrient intakes (1 study) • Diet quality/ food group/ nutrient intakes in WIC households (1 study)
Child development and academic achievement (KQ2)	**May be associated (Low SOE)** • Maternal participation and better child cognitive development (2 studies)	•Child participation and cognitive development (1 study) •Social development (1 study) •Motor development (1 study) •Communication and adaptive behavior (maternal WIC 1 study) (child WIC 1 study) •Developmental risk (1 study) •Academic achievement (1 study)

KQ= Key Questions; NICU = neonatal intensive care unit; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children

Birth Outcomes and Infant Mortality

We found that maternal WIC participation may be associated with lower risk of low birth weight and with lower risk of preterm birth. These findings confirm and extend the findings from the prior review.[5] Here we report reductions in risk on the order of 11% to 24% for low birth weight and 10% to 15% for preterm delivery. Notably, one study reported that WIC participation was associated with a 10% decrease in preterm birth that was similar among the racial and ethnic groups studied.[26] In 1992, the Government Accounting Office Study (GAO HRD 92-18) reported a summary reduction in risk of 25% for low birth weight.[116] The USDA 2012 review – which reported only direction and statistical significance –and an earlier review by Bitler in 2005 indicated greater reductions in risk of low birth weight and preterm delivery on the order of 10-40%.[5, 117] Most of the studies identified in the current review and the prior reviews used analytic strategies to address selection bias and confounding.[5, 117] However, the pregnancies reported in the 2012 review[5] occurred between 1988 and 2004 (overlapping with the GAO report). The risk estimates may be affected by differences over time in socioeconomic factors, who becomes pregnant, duration of pregnancy at enrollment in WIC, or access to and timing of entry into prenatal care (regardless of adjustment procedures). Most of the studies used Medicaid participation to identify WIC-eligible participants, and over time Medicaid expansion has altered the characteristics of the prenatal Medicaid population and the WIC versus eligible non-WIC comparison. Taken together, the evidence is remarkable for showing reductions in adverse birth outcomes associated with WIC as a public health program providing supportive guidance, referral, supplemental food, nutrition education, and enhanced support for high-risk pregnancies.

The authors of the 2012 review[5] suggested that the reduction in low birth weight was mainly due to a reduction in preterm delivery. The IOM in 2005 estimated a societal economic cost of $51,600 for each preterm birth.[118] An economic evaluation of California WIC, using updated cost figures and an estimated preterm birth relative risk of 0.7 for WIC,[30] demonstrated an economic cost of $46,118 per preterm birth and a $2.48 return for each $1.00 spent on WIC.[119] Thus, evidence that WIC participation may be associated with improved birth outcomes implies that it could also lead to a reduction in health care costs and subsequent health complications in children given the known risks associated with low birth weight and prematurity.[120]

As part of Key Question 2, and based on two studies, we found new evidence that maternal WIC participation may be associated with lower risk of infant mortality. In one national study of Medicaid births from 2011-2017,[26] the overall adjusted risk reduction was 14% and similar (10% to 15%) for non-Hispanic Whites, non-Hispanic Blacks and Hispanic infants. For this outcome, we expanded our search to include studies published from 2000 onwards and included a study from Puerto Rico of births in 1994-95 which reported an adjusted 40 percent reduction in infant mortality. We identified but excluded three additional studies of WIC participation and infant mortality because the comparison group included ineligible non-WIC participants.[121-123] In two of these studies, a 25% to 40% reduced infant mortality risk was associated with WIC participation.[121, 122] The third study found no difference in risk overall, but a reduction in risk for infants of both Hispanic and Black women participating in WIC, and increased risk for infants born to White women participating in WIC.[123] Thus, at this time, the evidence is insufficient to determine whether the association between infant mortality reduction and WIC participation varies by race or ethnic group. As noted above, Medicaid expansion and the changing Medicaid population will affect estimated effect size over time. The national study adjusted for sociodemographic characteristics, clinical risk factors, receipt of prenatal care, and maternal smoking, and covariate adjustment will lower effect estimates compared with vital records

studies with limited information on covariates.[26] A 10% to 15% reduced risk of infant mortality is meaningful at the population level.

Child Diet Quality

The HEI score is used to assess adherence to the Dietary Guidelines starting at 2 years of age. We found that WIC participation was associated with a 3 to 4 point higher total HEI score for children 2 to 4 years of age. Greater consumption of whole grains, fruits, vegetables, and low-fat milk after 2 years of age would be associated with higher total HEI scores. In studies we reviewed, WIC children had greater consumption of 100% fruit juice, infant cereal/grains, and age-appropriate shifts from whole milk to low-fat milk. Greater consumption of 100% juice, whole grains, fruits and vegetables and age-appropriate shifts from whole milk to lower fat milk were also associated with the revised food package in studies of the 2009 food package change among WIC children. Although the evidence is limited, we also report that longer duration of WIC participation was associated with better overall diet quality as compared with shorter duration of participation, with corresponding better intakes of several food groups.

Few studies included in the 2012 review evaluated diet quality using the HEI.[5] That review concluded that WIC participation was associated with improved diet, based on higher intakes of vitamin and mineral (iron) intakes, and lower fat intakes. Only a few studies in this review evaluated nutrient intakes. Although we found some evidence of higher vitamin D intakes and lower saturated fat intakes, the evidence was insufficient to draw conclusions about these outcome measures. We include studies published into 2021 and our findings extend those of a systematic review of studies of child diet quality and the 2009 food package change published through 2014.[124]

The difference in total HEI scores between WIC participants and eligible non-participants is large, on the order of 0.3 to 0.4 standard deviations, and reflects meaningful differences in diet quality compared with eligible non-WIC participants. Kirkpatrick et al. suggested that changes of 0.5 SD would constitute a moderate effect, but they also suggested that the scientific question and methodological issues may affect this judgment.[125] The total HEI-2010 scores of 53 to 59 for WIC children are lower but generally consistent with total HEI scores for the general population 2 years and older over the same time period.[126] It is well understood that food preferences and dietary patterns are established early and tend to persist throughout childhood.[127] Poor diet quality is a contributor to excess weight, a condition that develops in early childhood and can track into adulthood.[128, 129]

We identified a few dietary studies of pregnant women specifically, and several that focused on maternal caregivers of WIC children. These studies indicated that HEI scores are 2 to 3 points higher for WIC participants during pregnancy and 1 to 3 points higher for maternal caregivers of WIC children, with additional evidence for greater consumption of whole grains, low-fat milk and fruits and vegetables. The household purchasing studies provided evidence of reductions in purchasing of refined grains and increased purchases of whole grains, reductions in whole milk and increased purchases of low-fat milk, and although more variable – increased purchases of fruits and vegetable. Taken together, the evidence is fairly robust that WIC participation and exposure to the revised food package are associated with improved diet quality of children, pregnant women, and women living in WIC households.

Child Anthropometric Status or Growth Outcomes

Child overweight and obesity are public health concerns in the US. Although some earlier studies suggested that WIC participation was associated with overweight or obesity, the 2012 review was unable to draw conclusions between WIC participation and infant and child anthropometric outcomes.[5] Many components of the WIC food package were changed in 2009 to align with the DGA and reduce the likelihood of child overweight and obesity in the preschool years. Although many studies were identified for the review, we found little evidence comparing risk of overweight and obesity in children 2 to 4 years between WIC participants and eligible non-participants. This evidence gap relates to the relative lack of surveillance data of non-participating U.S. children. In contrast, 11 studies provided indirect evidence in that they reported associations of child overweight and obesity with the 2009 food package change among child WIC participants. Studies suggested that the revised food package was associated with a 10% lower risk of overweight and obesity in children 2 to 4 years of age.

Through a set of studies of WLZ growth velocity in matched WIC children from California, we summarized evidence that the revised food package was associated with slower growth velocity between 0 to 4 years. This finding may explain the lower risk of overweight and obesity in children 2 to 4 years associated with the revised food package. The studies identified a large reduction in WLZ from 6 to 12 months of age associated with the revised food package that was evident for all food packages other than the fully breastfed package. These findings await replication in other WIC populations. Further research may unpack the pathways through which the 2009 food package change has slowed growth velocity and lowered risk of later overweight and obesity.

Studies of national data of WIC children 2 to 4 years of age identified a change in the trends for the annual prevalence of child overweight and obesity from 2010 onwards, indicating a flattening and decline in the prevalence of overweight and obesity. A recently published national study of the prevalence of high weight-for-length among WIC children 6 to 23 months of age also reported a decline from 2010–2014 with a flattening through 2018.[130] Over this time period the prevalence of overweight and obesity for all U.S. children under 5 years of age declined from 2011–2014, but then increased through 2016.[131] Thus, the trends for WIC children do not mirror the secular trends of the general population. What a 10 percent reduction in risk of overweight and obesity means for individual children 2 to 4 years of age is unclear, but overweight tends to track into adulthood. Thus, prevention during early childhood is important for long-term well-being. At the population level, small reductions in childhood obesity would be associated with reductions in risk of future obesity and may eventually lead to lower cardiovascular disease burden in adulthood.[132, 133]

Breastfeeding Outcomes

In the 2012 review of the WIC program,[5] some evidence suggested that prior to 2009, WIC participants were less likely to breastfeed than eligible non-participants. In part, the 2009 food package changes and extension of maternal WIC participation postpartum were designed to enhance support for breastfeeding initiation and duration. Overall, the evidence presented here suggests only negligible differences in breastfeeding initiation between WIC participants and eligible non-participants. Across studies of breastfeeding initiation among WIC participants, the trends before and after the 2009 food package change show no marked change after the revision, also suggesting negligible change as a result of the food package change. With respect to the

outcomes of breastfeeding duration and exclusivity, we found insufficient direct evidence with respect to WIC participation, but some evidence of greater breastfeeding exclusivity in studies of the 2009 food package change among WIC participants.

These results are somewhat unexpected given the attention placed on breastfeeding promotion and support in the WIC program. That said, over the time period of assembled evidence, we found gradual upward trends in breastfeeding initiation, and to a lesser extent breastfeeding duration, with steady increases across multiple racial and ethnic groups and some indication of reduced racial/ethnic disparities in initiation between WIC participants and eligible non-participants (a disparity discussed in the 2012 report).[5] WIC services were in place prior to 2009 to support breastfeeding, including access to peer counselors and certified lactation consultants, prenatal education, and provision of breast pumps.[134, 135] Therefore, studies of the 2009 food package change evaluated breastfeeding outcomes associated with enhanced food packages for breastfeeding mothers and changes in formula provisions based on breastfeeding status. Interpretation of the study findings is further complicated by the fact that the Surgeon General's Call to Action to Support Breastfeeding[136] was released in 2011 and led to comprehensive public health action to support breastfeeding. Thus, teasing out what WIC participation alone means for this outcome is difficult.

Child Health and Development Outcomes

As part of the WIC program, professionals inquire about pediatric care access and immunization status and make referrals for both services. Thus, WIC participation may be associated with small positive impact on these outcomes. Identified studies reported small positive associations between, for example, prenatal WIC participation and well-child visits, and child WIC participation and vaccine coverage. The evidence for either outcome is limited and insufficient. More studies on health care utilization were conducted prior to 2009 and were included in the 2012 review.[5] Based on evidence from six studies, the 2012 review concluded that child and or maternal participation in WIC was associated with greater utilization of both preventive and curative health care services. In the 2012 review, based on three studies (one of which was included here), they also considered the evidence insufficient to draw conclusions regarding WIC participation and immunization coverage.

WIC participation may be positively associated with child development through improved prenatal nutrition, birth outcomes, breastfeeding, and partnerships with organizations with a shared mission to promote child development (e.g., Head Start). The 2012 review identified only one 2008 study (dissertation) of WIC participation and child development, and it presented mixed findings for outcomes at 9 and 24 months.[5, 137] Based on the findings of two studies (one used a difference in difference analysis with covariate adjustment and the other used a maternal fixed-effects analysis), we concluded that maternal WIC participation may be associated with greater cognitive development scores. The evidence was insufficient regarding child participation or other developmental outcomes during early childhood or academic achievement.

Maternal Health, Morbidity and Mortality

Multiple components of the WIC Program focus on supporting the nutrition and health of women during pregnancy, including referral to prenatal care, nutrition education and supplemental foods, and enhanced support for high-risk pregnancies. Despite evidence that maternal WIC participation was associated with improved birth outcomes and reduced infant mortality, a major finding of this review was the overall lack of studies evaluating maternal WIC

participation and maternal health outcomes. For important outcomes of maternal mortality and morbidity no studies were identified. There are multiple pathways through which WIC participation could contribute to lower pregnancy-related morbidity and mortality, and to reduced economic, racial, or ethnic disparities in these outcomes.[138] Although studies have been able to link birth and death records and information on WIC participation to evaluate infant mortality, none have linked data sources at scale to assess how WIC participation is related to maternal mortality. Most of the evidence regarding maternal morbidities (preeclampsia, gestational diabetes) was reported in one large, national pre-post study using a difference-in differences analysis in which WIC participants were compared with the general population (of those eligible and not eligible for WIC).[25] That study, along with a direct comparison of WIC-eligible participants with eligible non-participants reported reduced risk of excess gestational weight gain. One study reported a 2-point higher HEI score for WIC participants during pregnancy compared with eligible non-participants. Thus, the evidence is insufficient to draw conclusions regarding maternal WIC participation and maternal nutrition health outcomes.

Strengths and Limitations

This is the first systematic review to specifically address the association of WIC participation with a wide range of maternal and child outcomes and to consider evidence on how these outcomes are associated with the 2009 food package change. The evidence base on which to draw conclusions spans most of the U.S. Published studies leveraged federal and state surveillance systems, vital statistics, and federal studies, and a significant proportion were investigator initiated. We included studies that compared outcomes between WIC participants and eligible non-participants as providing direct evidence regarding the key questions. We presented separately the studies conducted among WIC participants. These studies, which largely focused on differences in outcomes before and after the 2009 food package change, provided indirect evidence regarding the key questions about the association of outcomes with WIC participation compared to eligible non-participants. Presenting the results in separate tables and text clarifies the nature and types of evidence available while highlighting gaps in direct evidence on the key questions. We limited our search to studies with data since 2009 to provide the most current evidence available to address the key questions, but we expanded our search for three outcomes (infant and maternal mortality, and child development) to include those with data since 2000. This strategy enabled us to include additional studies of infant mortality.

It is important to consider limitations in the evidence. First, because WIC is a federal program available to all those are eligible, none of the evidence to address the key questions resulted from RCTs. Other than the limited number of studies evaluating an outcome, this is the major reason that none of the outcomes had high SOE. Most studies used covariate adjustment, and some used stronger methods involving matched samples or propensity scoring. That said, a major limitation of observational studies is risk of bias due to residual confounding. The distinction between moderate or low SOE depended on the number of studies, the study design, methodologic rigor, consistency of the findings, and appropriate adjustment to address confounding and/or selection bias. Directness of the evidence for the key question was also a factor, and this lowered the SOE for studies involving WIC participants only. Second, many studies had a high risk of measurement bias for determining WIC exposure because exposure to WIC was based on self-reported WIC participation (either yes or no) at the time of the study with little clarification regarding benefit issuance or duration of participation. Third, the potential for selection bias must be acknowledged because income-eligible women, caregivers, and families

decide whether or not to participate in WIC. Studies of WIC participation find that early entry and later exit from WIC are associated with greater economic disadvantage (among those WIC eligible) indicating the potential for negative bias in studies.[12, 13, 15] Some studies have identified that child retention in WIC may be associated with positive health behaviors (such as breastfeeding and seeking support and nutritional advice).[13, 14] Analytic approaches involving matching, propensity scoring, instrumental variables, or selecting for consecutive pregnancies or siblings, address this bias as well as additional sources of unmeasured confounding. Although many studies used these approaches, small sample investigator-initiated studies relied on limited covariate adjustment and were identified as having high risk of bias. Thus, when considering the SOE, conclusions must balance evidence across studies with varying risk of bias. Because of the heterogeneity of studies with respect to study design, study population, comparisons, and measurement of outcomes, we were unable to synthesize the findings using meta-analysis. Finally, we did not assess potential reporting bias because of the lack of reliable methods for doing so with observational studies.[139]

The evidence had additional limitations with respect to specific outcomes. First, no studies were identified for some outcomes, and for some outcomes only one or two studies were identified. For some child outcomes only studies considering maternal WIC participation were identified. Some of the reasons for the paucity of evidence relate to limitations in the data sources that can be leveraged to study WIC. For example, to evaluate the outcome of maternal mortality, death records must indicate a cause and temporal relationship with pregnancy, indicate WIC participation, and multiple key covariates.[140] A second example is the lack of national sources of data that address questions regarding gestational weight gain, maternal morbidities, dietary outcomes during pregnancy and postpartum, and breastfeeding. Third, a limitation to the evidence for dietary outcomes was that the aspects of diet reported varied across studies. Although heterogeneity in reporting is expected, it can lead to questions of reporting bias. The lack of inclusion of recent studies on WIC participation and food security was unexpected. A few studies published after 2009 were excluded because they lacked data since 2009; for example, the paper by Kreider et al. 2016[141] analyzed NHANES data from 1999 to 2008. They found that WIC participation was associated with a reduction in the prevalence of child food insecurity by at least 3.6 percentage points which was considered a 20 percent reduction.

Included in the scope for the review were questions about differences in outcomes based on duration of participation in WIC and whether the association between WIC participation and outcomes varied by participant characteristics, including maternal age, race/ethnicity, geographic location, education, employment status, marital status, or housing. With the exception of a few studies focused on the duration of WIC participation or that stratified results by maternal race/ethnicity, it is striking that we identified few studies addressing questions about WIC participation and outcomes amongst these groups, about differential benefits associated with WIC participation, or how WIC may be addressing inequities in outcomes for specific vulnerable groups.

Applicability

A number of factors could impact the applicability of our findings. The evidence base was broad in terms of geographic distribution (state representation), and the use of national surveillance data to address outcomes overall and by state. The findings should be generally applicable throughout the U.S. however, for some outcomes, the evidence comes from multiple studies from a single data source. For example, multiple studies of WIC participation and

childhood weight were conducted in Los Angeles County, California often with the same data source. Four of ten studies on household purchasing practices were from New England with some using the same data source. Because many outcomes result from behavioral decisions made within a socio-ecological setting, the generalizability of the evidence across the nation is reasonable but not certain.

As noted above, the evidence base was largely insufficient to address the sub-questions under key questions 1 and 2 regarding the effect of the duration of WIC participation or the differential effects among different subgroups. For some outcomes, results were stratified or compared by race or ethnic groups, but often results were not reported for Asian American or Native American women, infants, and children. One study used data from the NATFAN study and reported findings on food group consumption changes before and after the 2009 food package changes in a sample of 65 to 71 percent Native American children 2 to 4 years.[91]

Implications for Clinical Practice, Education, Research, or Health Policy

The findings of this report should help to inform decision-making at both the clinical and policy levels, and to identify areas for future research. Although 77 quantitative studies were included in the review, for many outcomes the evidence was insufficient to draw definitive conclusions. For outcomes with more studies, inconsistency of results and potential risk of bias led to conclusions with low or insufficient SOE. For all outcomes in this review, new and/or more rigorous research with stronger analytic (causal inference) methods are needed.

For clinicians, including pediatricians, obstetricians, and dietitians who provide direct medical care to women, infants, and children, we summarized the most recent evidence on WIC services and how participation in the WIC program may contribute to improved obstetric and pediatric health outcomes. The evidence that the 2009 revised WIC food package is likely to be associated with improved purchasing and consumption of healthy food groups is also relevant to patient care related to overweight and chronic disease. Increased duration of child participation in WIC may further establish healthy eating patterns and reduce the likelihood of child overweight and obesity. The evidence highlights a role for clinicians in asking women about WIC participation at the first and subsequent prenatal visits, and in asking families about WIC participation and recommending continued child participation in WIC to age 5 years. Qualitative research identified differences in advice between medical providers and WIC professionals during pregnancy and infancy, suggesting both a need and an opportunity for more coordination.

In contrast, the summarized evidence indicated negligible effects of WIC participation on indicators of breastfeeding initiation and insufficient evidence on breastfeeding duration or exclusivity. As noted earlier, the incorporation of services to support breastfeeding occurred prior to 2009, and the 2009 food package change incentivized breastfeeding through an expanded food package for fully breastfeeding women, and extended WIC benefits for partially breastfeeding women to one year postpartum. Few studies evaluated dietary outcomes among women postpartum. We identified some evidence that the 2009 food package change was associated with greater breastfeeding exclusivity, however, one qualitative study indicated that the enhanced food package for breastfeeding mothers would not affect decisions regarding breastfeeding.[78] Evidence from a series of included studies on the BMI status at 2 to 4 years of WIC children identify important differences in growth velocity in later infancy that vary by the type of food package assigned to infants (based on caregiver decisions). Lowest risk was associated with receipt of the fully breastfeeding food package and with the duration of receipt,

which means breastfeeding initiation and duration were each associated with lower risk of a child being overweight. Hence a better understanding of food package choices and what they mean for mothers and infants is of high priority. Nevertheless, through this report, clinicians can be informed about WIC support for breastfeeding, mixed and formula feeding choices, and improved nutrition from birth to age 5 years.

The evidence summarized here is relevant and important for nutritionists and practitioners working in WIC and the broader public health community. WIC staff should understand the evidence regarding WIC participation and maternal, infant, and child outcomes, and how the 2009 revised food package may have affected outcomes. This is particularly important in the area of child diet and risk of overweight and obesity. Evidence from this review indicated that household WIC participation is associated with increased purchasing of whole grain foods and low-fat milks, with only slight use of non-WIC funds to maintain intakes of refined grains and whole milk. These findings are consistent with the dietary evidence that WIC participation is associated with improved diet quality through greater whole grain and low-fat milk intakes. The lack of evidence on dietary outcomes related to prenatal and postpartum WIC participation is surprising. The findings related to WIC participation and greater fruit and vegetable consumption were less clear. Some of the qualitative studies identified caregiver uncertainties about whether specific vegetables qualified and cited gaps in vendor knowledge that created barriers to purchasing. These factors led to negative feelings about this component of the food package. Thus, rigorous studies on this important dietary component are needed to identify how WIC resources can improve consumption.

As detailed in the review, changes in consumption were associated with 2 to 4 point differences in total HEI score that correspond to effect sizes on the order of 0.2 to 0.4 SD. One study[104] reported that a household-level HEI was about two points higher overall but was nine points higher during weeks when WIC funds were used, reminding us that WIC benefits result in the periodic provision of supplemental nutritious foods to participants. Thus, reported differences in diet quality across studies can be related to methodological decisions about data collection relative to benefit issuance and redemption, rather than differences attributable to WIC participation or services per se. In the future, findings related to diet quality should be standardized to address this source of bias.

This review identifies important areas for research on WIC participation and outcomes for women, infants, and children. Some areas such as research on breastfeeding and dietary outcomes have already been mentioned, and here we highlight other important areas. First, investigators need a comprehensive research agenda on maternal WIC participation and maternal mortality, morbidity (including anemia, preeclampsia, gestational diabetes, and hypertension), and well-being during pregnancy and postpartum. This research should evaluate how WIC participation is associated with outcomes and unpack whether these associations vary by participant characteristics. The evidence regarding reduced low birth weight and preterm delivery associated with WIC participation suggests the potential for identifying WIC-associated improvements in maternal diet and health during pregnancy. This would further refine the pathways through which WIC participation is associated with these outcomes. Second, more evidence is needed regarding infant and child health outcomes associated with maternal and/or WIC participation, including preventive and treatment visits, and immunization coverage. These are important areas for child health outcomes and yet, between the prior review and the current report, the evidence base has expanded only modestly. Third, we need more research on WIC participation and child growth outcomes leading to status measures including high weight status,

overweight, and obesity. This would require new longitudinal studies of WIC participants with WIC-eligible non-participants. Fourth, we need new comprehensive longitudinal studies on child development outcomes including academic performance because limited data sources are currently available on these outcomes. Fifth, we need studies on WIC participation and food security to understand how WIC participation is associated with food security and whether it varies by duration of participation or by participant characteristics. Finally, more research is needed to understand WIC participation and retention decision making to inform and address selection bias within all WIC-related research. Finally, we call for the use of research designs that better address selection bias and confounding to enhance the rigor of future evidence on maternal, infant, and child outcomes associated with WIC participation. Use of such designs would help to address questions about outcomes in sub-groups of the population.

Evidence from this review should be of interest to policy makers at the state and federal levels in order to determine whether changes should be made in the WIC program and/or policy to further improve dietary and health outcomes for women and children. The results of this review should be reassuring that, despite weaknesses in study design and analytic methodologies, current evidence suggests improvement in maternal, infant, and child outcomes associated with WIC participation and with the 2009 food package change. Recommendations from a 2006 IOM report led to those 2009 revisions. A second report in 2017 recommended further revisions to the food packages to further align with the 2015–2020 DGA and to support breastfeeding.[7, 142] However, these recommendations have not yet been enacted. Concurrently, work began to expand the DGA for pregnancy and birth to 24 months, and in late 2020 the DGA 2020–2025 was released.[10] The results of this review may provide an evidence base for considering the impact of prior recommendations and for the implementation of the new guidelines within WIC to further support diet and health outcomes for women, infants, and children.

Conclusions

The WIC program was established to safeguard the health of low-income women, infants, and children less than five years old who are at nutritional risk, by providing nutritious supplemental foods, nutrition education, breastfeeding support, and referrals to other health and social service programs. This systematic review assessed the recent landscape of WIC research to synthesize findings related to key health and dietary outcomes for WIC participants. Findings related to improvements in birth outcomes, infant mortality, and diet quality among children all support WIC's standing as an important part of the U.S. public health infrastructure. This review also highlights research gaps that point to a need for further investigation, using high quality methods, to better understand the relationship between WIC participation and outcomes. Research gaps pertaining to differential effects by key subgroups (such as race/ethnicity) also highlight the need for further high-quality research across these subgroups for all outcomes and show the importance of diverse representation in policy research.

References

1. WIC Data Tables. US Department of Agriculture; 2021. https://www.fns.usda.gov/pd/wic-program. Accessed on August 17, 2021.

2. WIC Nutrition Risk Criteria. US Department of Agriculture; 2011. https://www.fns.usda.gov/wic/nutrition-risk-criteria. Accessed on September 17, 2021.

3. National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2018 With Updated Estimates for 2016 and 2017. US Department of Agriculture; 2021. https://www.fns.usda.gov/wic/national-and-state-level-estimates-wic-eligibility-and-wic-program-reach-2018-updated. Accessed on August 17, 2021.

4. Fox MK, Hamilton W, Lin BH. Effects of Food Assistance and Nutrition Programs on Nutrition and Health: Volume 3, Literature Review. U.S. Department of Agriculture. Washington, DC: 2004. https://www.ers.usda.gov/publications/pub-details/?pubid=46574

5. Colman S, Nichols-Barrer IP, REdline JE, et al. Effects of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC): A Review of Recent Research U.S. Department of Agriculture. Alexandria, VA: 2012. https://fns-prod.azureedge.net/sites/default/files/WICMedicaidLitRev.pdf

6. USDA/FNS 7 CFR Part 246 [FNS–2006–0037] RIN 0584–AD77 Special Supplemental Nutrition Program for Women, Infants and Children (WIC): Revisions in the WIC Food Packages. Federal Register / Vol. 72, No. 234 U.S. Department of Agriculture. Alexandria, VA: 2007. http://www.gpo.gov/fdsys/pkg/FR-2007-12-06/pdf/E7-23033.pdf

7. National Academies of Sciences Engineering and Medicine. Review of WIC Food Packages: Improving Balance and Choice: Final Report The National Academies Press. Washington, DC: 2017.

8. Breastfeeding and the use of human milk. Pediatrics. 2012 Mar; 129(3):e827-41. doi: 10.1542/peds.2011-3552. PMID: 22371471.

9. U.S. Department of Health and Human Services, U.S. Department of Agriculture. Dietary Guidelines for Americans, 2005. 6 ed. Washington, DC: U.S. Government Printing Office; 2005.

10. Dietary Guidelines for Americans, 2020-2025. 9th Edition U.S. Department of Agriculture and U.S. Department of Health and Human Services. 2020. DietaryGuidelines.gov

11. PUBLIC LAW 111–296. 2010. https://fns-prod.azureedge.net/sites/default/files/PL_111-296.pdf. Accessed on March 12, 2021.

12. Currie J, Rossin-Slater M. Does the WIC program promote equality of opportunity in early life? In: Tach L, Dunifon R, Miller DL, eds. Confronting inequality: How policies and practices shape children's opportunities. Washington, DC: American Psychological Association; 2020:49-66.

13. Whaley SE, Martinez CE, Paolicelli C, et al. Predictors of WIC Participation Through 2 Years of Age. J Nutr Educ Behav. 2020 Jul;52(7):672-9. doi: 10.1016/j.jneb.2019.12.015. PMID: 32067886.

14. Whaley SE, Whaley M, Au LE, et al. Breastfeeding Is Associated With Higher Retention in WIC After Age 1. J Nutr Educ Behav. 2017 Nov-Dec;49(10):810-6.e1. doi: 10.1016/j.jneb.2017.07.003. PMID: 28890264.

15. Jacknowitz A, Tiehen L. Transitions into and out of the WIC Program: A cause for concern? Social Service Review. 2009; 83(2):151-83. doi: 10.1086/600111.

16. PRISMA. PRISMA; 2015. http://www.prisma-statement.org/. Accessed on March 15, 2021.

17. Supplemental Evidence and Data Request on Maternal and Childhood Outcomes Associated With the Special Supplemental Nutrition Program for Women, Infants and Children (WIC). National Archives; 2020. https://www.federalregister.gov/documents/2020/12/16/2020-27645/supplemental-evidence-and-data-request-on-maternal-and-childhood-outcomes-associated-with-the. Accessed on August 20, 2021.

18. Quality Assessment Tool for Quantitative Studies. Effective Public Healthcare Panacea Project; 2021. https://www.ephpp.ca/quality-assessment-tool-for-quantitative-studies/. Accessed on March 12, 2021.

19. JBI Manual For Evidence Synthesis. JBI; 2020. https://wiki.jbi.global/display/MANUAL/2.1+Introduction+and+purpose+of+this+guidance. Accessed on March 12, 2021.

20. Methods Guide for Effectiveness and Comparative Effectiveness Reviews. AHRQ Publication No. 10(14)-EHC063-EF Agency for Healthcare Research and Quality. Rockville, MD: 2014. www.effectivehealthcare.ahrq.gov

21. Gleason S, Pooler J. The Effects of Changes in WIC Food Packages on Redemptions. Contractor and Cooperator Report No. 69 Altarum Institute. 2011. https://naldc.nal.usda.gov/download/50613/PDF

22. Borger C, Zimmerman T, Vericker T, et al. WIC Infant and Toddler Feeding Practices Study-2: Fourth Year Report Food and Nutrition Service, U.S. Department of Agriculture. Alexandria, VA: 2020. https://www.fns.usda.gov/wic/infant-and-toddler-feeding-practices-study-2-fourth-year-report

23. Weinfield NS, Borger C, Zimmerman T, et al. WIC Infant and Toddler Feeding Practices Study-2: Third Year Report Food and Nutrition Service, U.S. Department of Agriculture. Alexandria, VA: 2019. https://www.fns.usda.gov/wic/wic-infant-and-toddler-feeding-practices-study-2-third-year-report

24. Sonchak L. The impact of WIC on breastfeeding initiation and gestational weight gain: Case study of South Carolina Medicaid mothers. Children and Youth Services Review. 2017;79:115-25. doi: 10.1016/j.childyouth.2017.05.024.

25. Hamad R, Collin DF, Baer RJ, et al. Association of Revised WIC Food Package With Perinatal and Birth Outcomes: A Quasi-Experimental Study. JAMA Pediatr. 2019 Jul 1;173(9):845-52. doi: 10.1001/jamapediatrics.2019.1706. PMID: 31260072.

26. Soneji S, Beltrán-Sánchez H. Association of Special Supplemental Nutrition Program for Women, Infants, and Children With Preterm Birth and Infant Mortality. JAMA Netw Open. 2019 Dec 2;2(12):e1916722. doi: 10.1001/jamanetworkopen.2019.16722. PMID: 31800070.

27. Ma X, Liu J, Smith M. WIC participation and breastfeeding in South Carolina: updates from PRAMS 2009-2010. Matern Child Health J. 2014 Jul;18(5):1271-9. doi: 10.1007/s10995-013-1362-2. PMID: 24057992.

28. Koumans EH, Harrison A, House LD, et al. Characteristics associated with lack of HIV testing during pregnancy and delivery in 36 U.S. states, 2004-2013. Int J STD AIDS. 2018 Oct;29(12):1225-33. doi: 10.1177/0956462418780053. PMID: 29969977.

29. Baer RJ, Altman MR, Oltman SP, et al. Maternal factors influencing late entry into prenatal care: a stratified analysis by race or ethnicity and insurance status. J Matern Fetal Neonatal Med. 2019 Oct;32(20):3336-42. doi: 10.1080/14767058.2018.1463366. PMID: 29631462.

30. Fingar KR, Lob SH, Dove MS, et al. Reassessing the Association between WIC and Birth Outcomes Using a Fetuses-at-Risk Approach. Matern Child Health J. 2017 Apr;21(4):825-35. doi: 10.1007/s10995-016-2176-9. PMID: 27531011.

31. Sonchak L. The Impact of WIC on Birth Outcomes: New Evidence from South Carolina. Matern Child Health J. 2016 Jul;20(7):1518-25.

doi: 10.1007/s10995-016-1951-y. PMID: 26976280.

32. Rhee J, Fabian MP, Ettinger de Cuba S, et al. Effects of Maternal Homelessness, Supplemental Nutrition Programs, and Prenatal PM(2.5) on Birthweight. Int J Environ Res Public Health. 2019 Oct 28;16(21)doi: 10.3390/ijerph16214154. PMID: 31661898.

33. El-Bastawissi AY, Peters R, Sasseen K, et al. Effect of the Washington Special Supplemental Nutrition Program for Women, Infants and Children (WIC) on pregnancy outcomes. Matern Child Health J. 2007 Nov;11(6):611-21. doi: 10.1007/s10995-007-0212-5. PMID: 17562153.

34. Guenther PM, Kirkpatrick SI, Reedy J, et al. The Healthy Eating Index-2010 is a valid and reliable measure of diet quality according to the 2010 Dietary Guidelines for Americans. J Nutr. 2014 Mar;144(3):399-407. doi: 10.3945/jn.113.183079. PMID: 24453128.

35. Guenther PM, Reedy J, Krebs-Smith SM. Development of the Healthy Eating Index-2005. J Am Diet Assoc. 2008 Nov;108(11):1896-901. doi: 10.1016/j.jada.2008.08.016. PMID: 18954580.

36. Hamad R, Batra A, Karasek D, et al. The Impact of the Revised WIC Food Package on Maternal Nutrition During Pregnancy and Postpartum. Am J Epidemiol. 2019 Aug 1;188(8):1493-502. doi: 10.1093/aje/kwz098. PMID: 31094428.

37. Oberle MM, Freese R, Shults J, et al. Impact of the 2009 WIC Food Package Changes on Maternal Dietary Quality. Journal of Hunger and Environmental Nutrition. 2020doi: 10.1080/19320248.2020.1724227.

38. Anderson CK, Walch TJ, Lindberg SM, et al. Excess Gestational Weight Gain in Low-Income Overweight and Obese Women: A Qualitative Study. J Nutr Educ Behav. 2015 Sep-Oct;47(5):404-11.e1. doi: 10.1016/j.jneb.2015.05.011. PMID: 26187348.

39. Kim LP, Koleilat M, Whaley SE. A Qualitative Study to Examine Perceptions and Barriers to Appropriate Gestational Weight Gain among Participants in the Special Supplemental Nutrition Program for Women Infants and Children Program. J Pregnancy. 2016;2016:4569742. doi: 10.1155/2016/4569742. PMID: 27403341.

40. Hromi-Fiedler A, Chapman D, Segura-Pérez S, et al. Barriers and Facilitators to Improve Fruit and Vegetable Intake Among WIC-Eligible Pregnant Latinas: An Application of the Health Action Process Approach Framework. J Nutr Educ Behav. 2016 Jul-Aug;48(7):468-77.e1. doi: 10.1016/j.jneb.2016.04.398. PMID: 27373861.

41. Angley M, Thorsten VR, Drews-Botsch C, et al. Association of participation in a supplemental nutrition program with stillbirth by race, ethnicity, and maternal characteristics. BMC Pregnancy Childbirth. 2018 Jul 24;18(1):306. doi: 10.1186/s12884-018-1920-0. PMID: 30041624.

42. Testa A, Jackson DB. Incarceration Exposure During Pregnancy and Infant Health: Moderation by Public Assistance. J Pediatr. 2020 Jun 23doi: 10.1016/j.jpeds.2020.06.055. PMID: 32590000.

43. Oropesa RS, Landale NS, Dávila AL. Poverty, prenatal care, and infant health in Puerto Rico. Soc Biol. 2001 Spring-Summer;48(1-2):44-66. doi: 10.1080/19485565.2001.9989027. PMID: 12194447.

44. Black MM, Quigg AM, Cook J, et al. WIC participation and attenuation of stress-related child health risks of household food insecurity and caregiver depressive symptoms. Arch Pediatr Adolesc Med. 2012 May;166(5):444-51. doi: 10.1001/archpediatrics.2012.1. PMID: 22566545.

45. Bersak T, Sonchak L. The Impact of WIC on Infant Immunizations and Health Care Utilization. Health Serv Res. 2018 Aug;53 Suppl 1(Suppl Suppl 1):2952-69. doi: 10.1111/1475-6773.12810. PMID: 29194615.

46. Casillas SM, Bednarczyk RA. Missed Opportunities for Hepatitis A Vaccination, National Immunization Survey-Child, 2013. J Pediatr. 2017 Aug;187:265-71.e1. doi: 10.1016/j.jpeds.2017.04.001. PMID: 28483064.

47. Thomas TN, Kolasa MS, Zhang F, et al. Assessing immunization interventions in the Women, Infants, and Children (WIC) program. Am J Prev Med. 2014 Nov;47(5):624-8. doi: 10.1016/j.amepre.2014.06.017. PMID: 25217817.

48. Smock L, Martelon M, Metallinos-Katsaras E, et al. Recovery From Malnutrition Among Refugee Children Following Participation in the Special Supplemental Nutrition for Women, Infants, and Children (WIC) Program in Massachusetts, 1998-2010. J Public Health Manag Pract. 2020 Jan/Feb;26(1):71-9. doi: 10.1097/phh.0000000000000995. PMID: 30969273.

49. Feldman-Winter L, Burnham L, Grossman X, et al. Weight gain in the first week of life predicts overweight at 2 years: A prospective cohort study. Matern Child Nutr. 2018 Jan;14(1)doi: 10.1111/mcn.12472. PMID: 28636245.

50. Pan L, Freedman DS, Park S, et al. Changes in Obesity Among US Children Aged 2 Through 4 Years Enrolled in WIC During 2010-2016. Jama. 2019 Jun 18;321(23):2364-6. doi: 10.1001/jama.2019.5051. PMID: 31211336.

51. Pan L, Freedman DS, Sharma AJ, et al. Trends in Obesity Among Participants Aged 2-4 Years in the Special Supplemental Nutrition Program for Women, Infants, and Children - United States, 2000-2014. MMWR Morb Mortal Wkly Rep. 2016 Nov 18;65(45):1256-60. doi: 10.15585/mmwr.mm6545a2. PMID: 27855143.

52. Chaparro MP, Anderson CE, Crespi CM, et al. The new child food package is associated with reduced obesity risk among formula fed infants participating in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) in Los Angeles County, California, 2003-2016. Int J Behav Nutr Phys Act. 2020 Feb 10;17(1):18. doi: 10.1186/s12966-020-0921-3. PMID: 32041634.

53. Chaparro MP, Wang MC, Anderson CE, et al. The Association between the 2009 WIC Food Package Change and Early Childhood Obesity Risk Varies by Type of Infant Package Received. J Acad Nutr Diet. 2020 Mar;120(3):371-85. doi: 10.1016/j.jand.2019.09.014. PMID: 31831385.

54. Chaparro MP, Crespi CM, Anderson CE, et al. The 2009 Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food package change and children's growth trajectories and obesity in Los Angeles County. Am J Clin Nutr. 2019 May 1;109(5):1414-21. doi: 10.1093/ajcn/nqy347. PMID: 31011750.

55. Anderson CE, Whaley SE, Crespi CM, et al. Every month matters: longitudinal associations between exclusive breastfeeding duration, child growth and obesity among WIC-participating children. J Epidemiol Community Health. 2020 Jul 1doi: 10.1136/jech-2019-213574. PMID: 32611693.

56. Chiasson MA, Scheinmann R, Hartel D, et al. Predictors of Obesity in a Cohort of Children Enrolled in WIC as Infants and Retained to 3 Years of Age. J Community Health. 2016 Feb;41(1):127-33. doi: 10.1007/s10900-015-0077-2. PMID: 26280211.

57. Chiasson MA, Findley SE, Sekhobo JP, et al. Changing WIC changes what children eat. Obesity (Silver Spring). 2013 Jul;21(7):1423-9. doi: 10.1002/oby.20295. PMID: 23703806.

58. Anderson CE, Crespi CM, Wang MC, et al. The neighborhood food environment modifies the effect of the 2009 WIC food package change on childhood obesity in Los Angeles County, California. BMC Public Health. 2020 May 13;20(1):678. doi: 10.1186/s12889-020-08779-2. PMID: 32404069.

59. Daepp MIG, Gortmaker SL, Wang YC, et al. WIC Food Package Changes: Trends in Childhood Obesity Prevalence. Pediatrics. 2019 May;143(5)doi: 10.1542/peds.2018-2841. PMID: 30936251.

60. Chaparro MP, Anderson CE, Crespi CM, et al. The effect of the 2009 WIC food package change on childhood obesity varies by gender and initial weight status in Los Angeles County. Pediatr Obes. 2019 Sep;14(9):e12526. doi: 10.1111/ijpo.12526. PMID: 30942561.

61. Guan A, Hamad R, Batra A, et al. The Revised WIC Food Package and Child Development: A Quasi-Experimental Study. Pediatrics. 2021 Feb;147(2)doi: 10.1542/peds.2020-1853. PMID: 33495370.

62. Lakshmanan A, Song AY, Flores-Fenlon N, et al. Association of WIC Participation and Growth and Developmental Outcomes in High-Risk Infants. Clin Pediatr (Phila). 2020 Jan;59(1):53-61. doi: 10.1177/0009922819884583. PMID: 31672064.

63. Joyce T, Reeder J. Changes in breastfeeding among WIC participants following implementation of the new food package. Matern Child Health J. 2015 Apr;19(4):868-76. doi: 10.1007/s10995-014-1588-7. PMID: 25095768.

64. Li K, Wen M, Reynolds M, et al. WIC Participation and Breastfeeding after the 2009 WIC Revision: A Propensity Score Approach. Int J Environ Res Public Health. 2019 Jul 24;16(15)doi: 10.3390/ijerph16152645. PMID: 31344937.

65. Barrera CM, Hamner HC, Perrine CG, et al. Timing of Introduction of Complementary Foods to US Infants, National Health and Nutrition Examination Survey 2009-2014. J Acad Nutr Diet. 2018 Mar;118(3):464-70. doi: 10.1016/j.jand.2017.10.020. PMID: 29307590.

66. Wilde P, Wolf A, Fernandes M, et al. Food-package assignments and breastfeeding initiation before and after a change in the Special Supplemental Nutrition Program for Women, Infants, and Children. Am J Clin Nutr. 2012 Sep;96(3):560-6. doi: 10.3945/ajcn.112.037622. PMID: 22836028.

67. Lee F, Edmunds LS, Cong X, et al. Trends in Breastfeeding Among Infants Enrolled in the Special Supplemental Nutrition Program for Women, Infants and Children - New York, 2002-2015. MMWR Morb Mortal Wkly Rep. 2017 Jun 16;66(23):610-4. doi: 10.15585/mmwr.mm6623a4. PMID: 28617769.

68. Langellier BA, Chaparro MP, Wang MC, et al. The new food package and breastfeeding outcomes among women, infants, and children participants in Los Angeles County. Am J Public Health. 2014 Feb;104 Suppl 1(Suppl 1):S112-8. doi: 10.2105/ajph.2013.301330. PMID: 24354843.

69. Reat AM, Crixell SH, Friedman BJ, et al. Comparison of Food Intake Among Infants and Toddlers Participating in a South Central Texas WIC Program Reveals Some Improvements After WIC Package Changes. Matern Child Health J. 2015 Aug;19(8):1834-41. doi: 10.1007/s10995-015-1697-y. PMID: 25656719.

70. Whaley SE, Koleilat M, Whaley M, et al. Impact of policy changes on infant feeding decisions among low-income women participating in the Special Supplemental Nutrition Program for Women, Infants, and Children. Am J Public Health. 2012 Dec;102(12):2269-73. doi: 10.2105/ajph.2012.300770. PMID: 23078467.

71. McCoy MB, Geppert J, Dech L, et al. Associations Between Peer Counseling and Breastfeeding Initiation and Duration: An Analysis of Minnesota Participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). Matern Child Health J. 2018 Jan;22(1):71-81. doi: 10.1007/s10995-017-2356-2. PMID: 28755046.

72. Gleason S, Wilkin MK, Sallack L, et al. Breastfeeding Duration Is Associated With WIC Site-Level Breastfeeding Support Practices. J Nutr Educ Behav. 2020 Jul;52(7):680-7. doi: 10.1016/j.jneb.2020.01.014. PMID: 32171671.

73. Almeida R, Alvarez Gutierrez S, Whaley SE, et al. A Qualitative Study of Breastfeeding and Formula-Feeding Mothers' Perceptions of and Experiences in WIC. J Nutr Educ Behav. 2020 Jun;52(6):615-25. doi: 10.1016/j.jneb.2019.12.006. PMID: 31955996.

74. Schindler-Ruwisch J, Roess A, Robert RC, et al. Determinants of Breastfeeding Initiation and Duration Among African American DC WIC Recipients: Perspectives of Recent Mothers. Womens Health Issues. 2019 Nov-Dec;29(6):513-21. doi: 10.1016/j.whi.2019.07.003. PMID: 31409521.

75. Scott A, Shreve M, Ayers B, et al. Breast-feeding perceptions, beliefs and experiences of

Marshallese migrants: an exploratory study. Public Health Nutr. 2016 Nov;19(16):3007-16. doi: 10.1017/s1368980016001221. PMID: 27230629.

76. Gross TT, Powell R, Anderson AK, et al. WIC peer counselors' perceptions of breastfeeding in African American women with lower incomes. J Hum Lact. 2015 Feb;31(1):99-110. doi: 10.1177/0890334414561061. PMID: 25480019.

77. Hohl S, Thompson B, Escareño M, et al. Cultural Norms in Conflict: Breastfeeding Among Hispanic Immigrants in Rural Washington State. Maternal & Child Health Journal. 2016;20(7):1549-57. doi: 10.1007/s10995-016-1954-8. PMID: 116170891. Language: English. Entry Date: 20160622. Revision Date: 20170703. Publication Type: Article.

78. Bedwell RM. The Impact of Federal Breastfeeding Policy Initiatives on Women's Breastfeeding Practices and Attitudes in Southern Indiana. Journal of Poverty. 2017;21(6):508-27. doi: 10.1080/10875549.2017.1348423.

79. Gross TT, Davis M, Anderson AK, et al. Long-Term Breastfeeding in African American Mothers. J Hum Lact. 2017 Feb;33(1):128-39. doi: 10.1177/0890334416680180. PMID: 28061039.

80. Isaacs S, Shriver L, Haldeman L. Qualitative analysis of maternal barriers and perceptions to participation in a federal supplemental nutrition program in rural appalachian North Carolina. J Appalachian Health. 2020;2(4):37–52. doi: doi.org/10.13023/jah.0204.06.

81. Ruiz M, Arroyo H, Dávila Torres R, et al. Qualitative Study on WIC Program Strategies to Promote Breastfeeding Practices in Puerto Rico: What do Nutritionist/Dietician's [sic] Think? Maternal & Child Health Journal. 2011;15(4):520-6. doi: 10.1007/s10995-010-0592-9.

82. Tester JM, Leung CW, Crawford PB. Revised WIC Food Package and Children's Diet Quality. Pediatrics. 2016 May;137(5)doi: 10.1542/peds.2015-3557. PMID: 27244804.

83. Guthrie JF, Catellier DJ, Jacquier EF, et al. WIC and non-WIC Infants and Children Differ in Usage of Some WIC-Provided Foods. J Nutr. 2018 Sep 1;148(suppl_3):1547s-56s. doi: 10.1093/jn/nxy157. PMID: 30247584.

84. Jun S, Catellier DJ, Eldridge AL, et al. Usual Nutrient Intakes from the Diets of US Children by WIC Participation and Income: Findings from the Feeding Infants and Toddlers Study (FITS) 2016. J Nutr. 2018 Sep 1;148(9s):1567s-74s. doi: 10.1093/jn/nxy059. PMID: 29878136.

85. Gu X, Tucker KL. Dietary quality of the US child and adolescent population: trends from 1999 to 2012 and associations with the use of federal nutrition assistance programs. Am J Clin Nutr. 2017 Jan;105(1):194-202. doi: 10.3945/ajcn.116.135095. PMID: 27881390.

86. Vercammen KA, Moran AJ, Zatz LY, et al. 100% Juice, Fruit, and Vegetable Intake Among Children in the Special Supplemental Nutrition Program for Women, Infants, and Children and Nonparticipants. Am J Prev Med. 2018 Jul;55(1):e11-e8. doi: 10.1016/j.amepre.2018.04.003. PMID: 29776784.

87. Hamner HC, Paolicelli C, Casavale KO, et al. Food and Beverage Intake From 12 to 23 Months by WIC Status. Pediatrics. 2019 Mar;143(3)doi: 10.1542/peds.2018-2274. PMID: 30733238.

88. Odoms-Young AM, Kong A, Schiffer LA, et al. Evaluating the initial impact of the revised Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food packages on dietary intake and home food availability in African-American and Hispanic families. Public Health Nutr. 2014 Jan;17(1):83-93. doi: 10.1017/s1368980013000761. PMID: 23544992.

89. Whaley SE, Ritchie LD, Spector P, et al. Revised WIC food package improves diets of WIC families. J Nutr Educ Behav. 2012 May-Jun;44(3):204-9. doi: 10.1016/j.jneb.2011.09.011. PMID: 22406013.

90. Guthrie JF, Anater AS, Hampton JC, et al. The Special Supplemental Nutrition Program for

Women, Infants, and Children is Associated with Several Changes in Nutrient Intakes and Food Consumption Patterns of Participating Infants and Young Children, 2008 Compared with 2016. J Nutr. 2020 Nov 19;150(11):2985-93. doi: 10.1093/jn/nxaa265. PMID: 33024989.

91. Ishdorj A, Capps Jr O. The effect of revised WIC food packages on native American children. American Journal of Agricultural Economics. 2013;95(5):1266-72. doi: 10.1093/ajae/aat030.

92. Meiqari L, Torre L, Gazmararian JA. Exploring the Impact of the New WIC Food Package on Low-Fat Milk Consumption Among WIC Recipients: A Pilot Study. J Health Care Poor Underserved. 2015 Aug;26(3):712-25. doi: 10.1353/hpu.2015.0092. PMID: 26320907.

93. Morshed AB, Davis SM, Greig EA, et al. Effect of WIC Food Package Changes on Dietary Intake of Preschool Children in New Mexico. Health Behav Policy Rev. 2015 Jan;2(1):3-12. doi: 10.14485/hbpr.2.1.1. PMID: 27668264.

94. Weinfield NS, Borger C, Gola AA. Breastfeeding Duration in a Low-Income Sample Is Associated With Child Diet Quality at Age Three. J Hum Lact. 2020 Feb 24:890334420903029. doi: 10.1177/0890334420903029. PMID: 32091965.

95. Weinfield NS, Borger C, Au LE, et al. Longer Participation in WIC Is Associated with Better Diet Quality in 24-Month-Old Children. J Acad Nutr Diet. 2020 Jun;120(6):963-71. doi: 10.1016/j.jand.2019.12.012. PMID: 32067936.

96. Kong A, Odoms-Young AM, Schiffer LA, et al. The 18-month impact of special supplemental nutrition program for women, infants, and children food package revisions on diets of recipient families. Am J Prev Med. 2014 Jun;46(6):543-51. doi: 10.1016/j.amepre.2014.01.021. PMID: 24842730.

97. Zimmer MC, Vernarelli JA. Changes in nutrient and food group intakes among children and women participating in the Special Supplemental Nutrition Program for Women, Infants, and Children: findings from the 2005-2008 and 2011-2014 National Health and Nutrition Examination Surveys. Public Health Nutr. 2019 Dec;22(18):3309-14. doi: 10.1017/s1368980019002702. PMID: 31566166.

98. Thornton HE, Crixell SH, Reat AM, et al. Differences in energy and micronutrient intakes among Central Texas WIC infants and toddlers after the package change. J Nutr Educ Behav. 2014 May-Jun;46(3 Suppl):S79-86. doi: 10.1016/j.jneb.2014.02.005. PMID: 24810001.

99. Perkins S, Daley A, Yerxa K, et al. The Effectiveness of the Expanded Food and Nutrition Education Program (EFNEP) on Diet Quality as Measured by the Healthy Eating Index. Am J Lifestyle Med. 2020 May-Jun;14(3):316-25. doi: 10.1177/1559827619872733. PMID: 32477034.

100. Oh M, Jensen HH, Rahkovsky I. Did revisions to the wic program affect household expenditures on whole grains? Applied Economic Perspectives and Policy. 2016;38(4):578-98. doi: 10.1093/aepp/ppw020.

101. Ng SW, Hollingsworth BA, Busey EA, et al. Federal Nutrition Program Revisions Impact Low-income Households' Food Purchases. Am J Prev Med. 2018 Mar;54(3):403-12. doi: 10.1016/j.amepre.2017.12.003. PMID: 29455757.

102. Stewart H, McLaughlin PW, Dong D, et al. WIC Households' Bread and Cold Cereal Purchases: When They Use Benefits Versus Paying Out of Pocket. Am J Health Promot. 2019 Jan;33(1):79-86. doi: 10.1177/0890117118778243. PMID: 29847997.

103. Litvak J, Parekh N, Juul F, et al. Food assistance programs and income are associated with the diet quality of grocery purchases for households consisting of women of reproductive age or young children. Prev Med. 2020 Sep;138:106149. doi: 10.1016/j.ypmed.2020.106149. PMID: 32473261.

104. Fang D, Thomsen MR, Nayga RM, Jr., et al. WIC Participation and Relative Quality of Household Food Purchases: Evidence from FoodAPS. Southern Economic Journal. 2019;86(1):83-105. doi: 10.1002/soej.12363.

105. Andreyeva T, Luedicke J, Henderson KE, et al. The positive effects of the revised milk and cheese allowances in the special supplemental nutrition program for women, infants, and children. J Acad Nutr Diet. 2014 Apr;114(4):622-30. doi: 10.1016/j.jand.2013.08.018. PMID: 24210878.

106. Andreyeva T, Luedicke J, Tripp AS, et al. Effects of reduced juice allowances in food packages for the women, infants, and children program. Pediatrics. 2013 May;131(5):919-27. doi: 10.1542/peds.2012-3471. PMID: 23629613.

107. Andreyeva T, Luedicke J. Incentivizing fruit and vegetable purchases among participants in the Special Supplemental Nutrition Program for Women, Infants, and Children. Public Health Nutr. 2015 Jan;18(1):33-41. doi: 10.1017/s1368980014000512. PMID: 24809502.

108. Andreyeva T, Luedicke J. Federal food package revisions: effects on purchases of whole-grain products. Am J Prev Med. 2013 Oct;45(4):422-9. doi: 10.1016/j.amepre.2013.05.009. PMID: 24050418.

109. Andreyeva T, Tripp AS. The healthfulness of food and beverage purchases after the federal food package revisions: The case of two New England states. Prev Med. 2016 Oct;91:204-10. doi: 10.1016/j.ypmed.2016.08.018. PMID: 27527573.

110. Robson SM, DeLuccia R, Baker S, et al. Qualitative Research on the Real-Time Decision Making of WIC Participants While Food Shopping: Use of Think-Aloud Methodology. J Acad Nutr Diet. 2020 Jan;120(1):111-9. doi: 10.1016/j.jand.2019.05.009. PMID: 31307943.

111. Bertmann FM, Barroso C, Ohri-Vachaspati P, et al. Women, infants, and children cash value voucher (CVV) use in Arizona: a qualitative exploration of barriers and strategies related to fruit and vegetable purchases. J Nutr Educ Behav. 2014 May-Jun;46(3 Suppl):S53-8. doi: 10.1016/j.jneb.2014.02.003. PMID: 24809997.

112. Weber SJ, Wichelecki J, Chavez N, et al. Understanding the factors influencing low-income caregivers' perceived value of a federal nutrition programme, the Special Supplemental Nutrition Program for Women, Infants and Children (WIC). Public Health Nutr. 2019 Apr;22(6):1056-65. doi: 10.1017/s1368980018003336. PMID: 30522548.

113. Beck AL, Takayama JI, Halpern-Felsher B, et al. Understanding how Latino parents choose beverages to serve to infants and toddlers. Matern Child Health J. 2014 Aug;18(6):1308-15. doi: 10.1007/s10995-013-1364-0. PMID: 24077961.

114. Arons A, Bolbocean C, Bush NR, et al. Participation in the special supplemental nutrition program for women, infants, and children is not associated with early childhood socioemotional development: Results from a longitudinal cohort study. Prev Med Rep. 2016 Dec;4:507-11. doi: 10.1016/j.pmedr.2016.09.004. PMID: 27688993.

115. Jackson MI. Early childhood WIC participation, cognitive development and academic achievement. Soc Sci Med. 2015 Feb;126:145-53. doi: 10.1016/j.socscimed.2014.12.018. PMID: 25555255.

116. Early Intervention: Federal investments like WIC can produce savings (GAO/HRD-92-18) US General Accounting Office. 1992. https://www.gao.gov/assets/hrd-92-18.pdf

117. Bitler MP, Currie J. Does WIC work? The effects of WIC on pregnancy and birth outcomes. J Policy Anal Manage. 2005 Winter;24(1):73-91. doi: 10.1002/pam.20070. PMID: 15584177.

118. Institute of Medicine Committee on Understanding Premature B, Assuring Healthy O. The National Academies Collection: Reports funded by National Institutes of Health. In: Behrman RE, Butler AS, eds. Preterm Birth: Causes, Consequences, and Prevention. Washington (DC): National Academies Press (US)

119. Nianogo RA, Wang MC, Basurto-Davila R, et al. Economic evaluation of California prenatal participation in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) to prevent preterm birth. Prev Med. 2019 Jul;124:42-9. doi: 10.1016/j.ypmed.2019.04.011. PMID: 30998955.

120. Nuyt AM, Lavoie JC, Mohamed I, et al. Adult Consequences of Extremely Preterm Birth: Cardiovascular and Metabolic Diseases Risk Factors, Mechanisms, and Prevention Avenues. Clin Perinatol. 2017 Jun;44(2):315-32. doi: 10.1016/j.clp.2017.01.010. PMID: 28477663.

121. Khanani I, Elam J, Hearn R, et al. The impact of prenatal WIC participation on infant mortality and racial disparities. Am J Public Health. 2010 Apr 1;100 Suppl 1(Suppl 1):S204-9. doi: 10.2105/ajph.2009.168922. PMID: 20147683.

122. Ratnasiri AWG, Lakshminrusimha S, Dieckmann RA, et al. Maternal and infant predictors of infant mortality in California, 2007-2015. PLoS One. 2020;15(8):e0236877. doi: 10.1371/journal.pone.0236877. PMID: 32760136.

123. Keene Woods N, Reyes J, Chesser A. Infant Mortality and Race in Kansas: Associations With Women, Infants, and Children Services. J Prim Care Community Health. 2016 Jul;7(3):194-8. doi: 10.1177/2150131916635572. PMID: 26936839.

124. Schultz DJ, Byker Shanks C, Houghtaling B. The Impact of the 2009 Special Supplemental Nutrition Program for Women, Infants, and Children Food Package Revisions on Participants: A Systematic Review. J Acad Nutr Diet. 2015 Nov;115(11):1832-46. doi: 10.1016/j.jand.2015.06.381. PMID: 26276067.

125. Kirkpatrick SI, Reedy J, Krebs-Smith SM, et al. Applications of the Healthy Eating Index for Surveillance, Epidemiology, and Intervention Research: Considerations and Caveats. J Acad Nutr Diet. 2018 Sep;118(9):1603-21. doi: 10.1016/j.jand.2018.05.020. PMID: 30146072.

126. Wilson MM, Reedy J, Krebs-Smith SM. American Diet Quality: Where It Is, Where It Is Heading, and What It Could Be. J Acad Nutr Diet. 2016 Feb;116(2):302-10.e1. doi: 10.1016/j.jand.2015.09.020. PMID: 26612769.

127. Nicklaus S, Boggio V, Chabanet C, et al. A prospective study of food variety seeking in childhood, adolescence and early adult life. Appetite. 2005 Jun;44(3):289-97. doi: 10.1016/j.appet.2005.01.006. PMID: 15927730.

128. Dattilo AM, Birch L, Krebs NF, et al. Need for early interventions in the prevention of pediatric overweight: a review and upcoming directions. J Obes. 2012;2012:123023. doi: 10.1155/2012/123023. PMID: 22675610.

129. Saavedra JM, Deming D, Dattilo A, et al. Lessons from the feeding infants and toddlers study in North America: what children eat, and implications for obesity prevention. Ann Nutr Metab. 2013;62 Suppl3:27-36. doi: 10.1159/000351538. PMID: 23970213.

130. Pan L, Blanck HM, Galuska DA, et al. Changes in High Weight-for-Length among Infants Enrolled in Special Supplemental Nutrition Program for Women, Infants, and Children during 2010-2018. Child Obes. 2021 Sep;17(6):408-19. doi: 10.1089/chi.2021.0055. PMID: 33960827.

131. Fryar CD, Carroll MD, Afful J. Prevalence of Overweight, Obesity, and Severe Obesity Among Children and Adolescents Aged 2–19 Years: United States, 1963–1965 Through 2017–2018 NCHS Health E-Stats. 2020.

132. O'Connor EA, Evans CV, Burda BU, et al. Screening for Obesity and Intervention for Weight Management in Children and Adolescents: Evidence Report and Systematic Review for the US Preventive Services Task Force. Jama. 2017 Jun 20;317(23):2427-44. doi: 10.1001/jama.2017.0332. PMID: 28632873.

133. Freedman DS, Khan LK, Dietz WH, et al. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa Heart Study. Pediatrics. 2001 Sep;108(3):712-8. doi: 10.1542/peds.108.3.712. PMID: 11533341.

134. Public Law 108 - 265 - Child Nutrition and WIC Reauthorization Act of 2004. US Government Publishing Office. https://www.govinfo.gov/app/details/PLAW-108publ265. Accessed on April 16, 2021.

135. Public Law 105 - 336 - William F. Goodling Child Nutrition Reauthorization Act of 1998. U.S. Government Publishing Office. https://www.govinfo.gov/app/details/PLAW-105publ336. Accessed on April 16, 2021.

136. Lowe NK. The Surgeon General's call to action to support breastfeeding. Journal of Obstetric, Gynecologic, & Neonatal Nursing: Clinical Scholarship for the Care of Women, Childbearing Families, & Newborns. 2011;40(4):387-9. doi: 10.1111/j.1552-6909.2011.01266.x. PMID: 2011-15711-001.

137. Rivera AC. Impact and process evaluation of prenatal WIC on maternal and infant outcomes: ProQuest Information & Learning; 2009.

138. The Role of WIC in Reducing Maternal Mortality Position Paper National WIC Association. 2020. https://s3.amazonaws.com/aws.upl/nwica.org/fy20_nwa_factsheet_reducing-maternal-mortality-position-paper.pdf

139. Mueller M, D'Addario M, Egger M, et al. Methods to systematically review and meta-analyse observational studies: a systematic scoping review of recommendations. BMC Med Res Methodol. 2018 May 21;18(1):44. doi: 10.1186/s12874-018-0495-9. PMID: 29783954.

140. Creanga AA. Maternal Mortality in the United States: A Review of Contemporary Data and Their Limitations. Clin Obstet Gynecol. 2018 Jun;61(2):296-306. doi: 10.1097/grf.0000000000000362. PMID: 29561285.

141. Kreider B, Pepper JV, Roy M. Identifying the effects of WIC on food insecurity among infants and children. Southern Economic Journal. 2016;82(4):1106-22. doi: 10.1002/soej.12078.

142. 2015 – 2020 Dietary Guidelines for Americans. 8th Edition U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015. https://health.gov/our-work/food-nutrition/previous-dietary-guidelines/2015