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# WIC-Medicaid II Feasibility Study: Final Report

Mathematica Policy Research ● September 2018

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**Food and Nutrition Service, Office of Policy Support** **September 2018**

# WIC–Medicaid II Feasibility Study: Final Report


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## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| APNCU | Adequacy of Prenatal Care Utilization |
| BMI | body mass index |
| CHIP | Children's Health Insurance Program |
| CDC | Centers for Disease Control and Prevention |
| CMCS | Center for Medicaid and CHIP Services |
| CMS | Centers for Medicare & Medicaid Services |
| DRG | diagnosis-related group |
| EPSDT | early and periodic screening, diagnosis, and treatment |
| ER | emergency room |
| FNS | Food and Nutrition Service |
| FPL | Federal poverty level |
| GED | general educational development (diploma) |
| ICD-9 | International Classification of Diseases, 9th ed. |
| IOM | Institute of Medicine |
| IPW | inverse probability weighting |
| IRB | institutional review board |
| ITO | Indian Tribal Organization |
| NICU | neonatal intensive care unit |
| NASEM | National Academies of Science, Engineering and Medicine |
| PRAMS | Pregnancy Risk Assessment Monitoring System |
| SD | standard deviation |
| SE | standard error |
| SGA | small-for-gestational-age |
| SNAP | Supplemental Nutrition Assistance Program |
| SPIRIT | Successful Partners in Reaching Innovative Technology |
| SSN | Social Security number |
| TANF | Temporary Assistance for Needy Families |
| USDA | U.S. Department of Agriculture |
| WIC | Special Supplemental Nutrition Program for Women, Infants, and Children |

| | |
|---|---|
| WM-I | WIC-Medicaid Study I |
| WM-II | WIC-Medicaid Study II Feasibility Study |

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# EXECUTIVE SUMMARY

The mission of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is to safeguard the health of low-income women, infants, and children up to age 5 who are at nutritional risk. The program provides a combination of services, including nutritious foods to supplement diets, nutrition education, breastfeeding support, and referrals to health care and social services.

This report presents findings from the WIC-Medicaid II Feasibility Study (WM-II). The goal of WM-II was to assess the feasibility of repeating and potentially expanding two previous studies within current (2010) policy and participation environments. These two studies looked at associations between WIC participation and health outcomes and Medicaid costs. The first study—the original WIC-Medicaid Study (WM-I)—found that prenatal WIC participation was associated with improved birth outcomes and savings in Medicaid costs (Devaney et al. 1990, 1991a, 1991b, 1992; Devaney and Schirm 1993). The second study, conducted by Buescher et al. (2003), found that WIC participation during childhood was associated with increased health care utilization and increased Medicaid costs, and concluded that WIC participation enhanced children's linkages to the health care system.

In the decades since these studies were conducted, much has changed in both the populations that participate in the WIC and Medicaid programs and the policies that govern these programs. In particular, major changes to WIC's supplemental food packages, implemented in 2009, have the potential to improve the dietary patterns, breastfeeding status, and health behaviors of WIC participants. In addition, advances in analytic methods and enhancements to the data available from birth certificates could lead to a more rigorous assessment of WIC's potential contribution to health-related outcomes and Medicaid costs.

In light of these changes, FNS sought to update the previous WIC-Medicaid studies and, in 2010, awarded a contract to Mathematica Policy Research to conduct WM-II; FNS recognized that replicating the previous studies could be difficult if it proved challenging to construct an adequate non-WIC comparison group or measure Medicaid costs for the increasingly large share of Medicaid beneficiaries enrolled in managed care. For this reason, WM-II started with a feasibility assessment that was limited to two States.

FNS and Mathematica jointly selected two States—Missouri and Oklahoma—to participate in WM-II. Selection of these two States was based on a variety of factors, including the availability of enhanced birth certificate data; whether Medicaid income-eligibility thresholds for pregnant women, infants, and children covered all WIC participants (so that everyone eligible for WIC was also eligible for Medicaid); the annual number of Medicaid-covered births (to ensure that the study would have adequate statistical power); and the design of the States' Medicaid programs (so the feasibility study could assess challenges associated with measuring Medicaid costs for beneficiaries enrolled in managed care).

## A. Approach to the study

The feasibility assessment focused on three overarching questions:

1. Can the administrative data required to update and expand the previous studies be obtained from two States?
2. Can these data be successfully linked to create the necessary analytic database for each State?
3. Can the analyses from the WM-I and Buescher et al. (2003) studies (hereafter referred to as the Buescher study) be updated or expanded by assessing additional outcomes, incorporating additional covariates, or using advanced analytic techniques?

If the knowledge gained in the feasibility assessment suggested that a rigorous assessment of the impacts of WIC participation was feasible, FNS had the option to expand the study to include five additional States.

To address the first and second questions, the study team requested statewide data files from WIC, Medicaid, and Vital Records agencies in the two study States and linked data from the three sources to create an analytic database for each State. In Oklahoma, where a State WIC agency and nine independent Indian Tribal Organizations (ITOs) provide WIC services, the study team requested WIC records from the State and each of the ITOs. In assessing the success of these processes and, by extension, the feasibility of expanding WM-II to additional States, the study team considered the completeness and quality of data provided by the two study States and the match rates achieved in creating linked analytic databases.

To address the third question, the study team designed two distinct analyses that would use the linked databases:

1. The **prenatal analysis** was modeled on WM-I and examined the associations between WIC participation during pregnancy and birth outcomes, other health-related outcomes, maternal behaviors, and Medicaid costs among Medicaid-covered births. The prenatal analysis compared outcomes for women who participated in WIC during their pregnancy and had a Medicaid-covered birth (and their infants) with outcomes for a comparison group of women who had a Medicaid-covered birth but did not participate in WIC during pregnancy (and their infants).
2. The **children's analysis** was modeled on the Buescher study and examined the associations between WIC participation during childhood and health care utilization, diagnosis and treatment of common childhood illnesses, and Medicaid costs. However, because the timeline for WM-II did not allow for the longitudinal design used in the Buescher study (which followed a cohort of children from birth to age 5), the WM-II design included a cross-section of children, ages 1 to 4 years, who were continuously enrolled in Medicaid during calendar year 2010. The analysis compared children enrolled in Medicaid in 2010 who had participated in WIC after their first birthday to a comparison group of children enrolled in Medicaid in 2010 who had not participated in WIC.

## B. Collecting and linking administrative data

**Defining the analysis samples.** The prenatal analysis examined Medicaid-covered births—that is, births for which Medicaid paid for the delivery or postpartum stay—during a 12-month period that began 6 months after the revised WIC food packages were implemented (October 2009 in Missouri and August 2009 in Oklahoma). The children's analysis included a cross-section of children born from July 2005 to June 2009 and continuously enrolled in Medicaid during calendar year 2010. Children were grouped into age cohorts based on their age in June 2010 (1-year-olds, 2-year-olds, 3-year-olds, and 4-year-olds). Because children were 1 to 4 years old at the time of data collection, WIC participants in the sample participated in WIC both before and after the 2009 changes to the WIC food packages.

**Creating the linked database.** Medicaid and Vital Records data for specific individuals were linked to identify analytic samples, measure outcomes, and construct covariates that would be used to account for differences between WIC participants and nonparticipants in maternal, child, and household characteristics. The resulting file was matched to WIC certification records and WIC voucher issuance and redemption records to identify WIC participants and nonparticipants and, among participants, to measure the duration and intensity of WIC participation. The process of linking administrative data files was analytically and technically challenging, as well as resource-intensive, but the study team ultimately achieved high match rates for both Missouri and Oklahoma for the prenatal and children's analyses. Match rates were equivalent to or higher than the match rates achieved in WM-I and the Buescher study and likely approached the upper bound possible because birth certificate data were not collected for out-of-State births covered by the Medicaid (cross-State Vital Records Agency agreements generally preclude States from sharing birth certificate data for citizens of other States). Medicaid beneficiaries who did not match to a birth certificate and, therefore, were not included in the linked database were similar to beneficiaries who were matched to a birth certificate.

**Sample sizes.** The linked database for the prenatal analysis in Missouri included 37,837 Medicaid-covered births, and the linked database for Oklahoma included 30,682 Medicaid-covered births. In both States, more than 70 percent of the mothers included in the linked database participated in WIC during their pregnancies. The linked database created for the children's analysis in Missouri included a cross-section of 110,198 children in Missouri and 63,297 children in Oklahoma. Depending on the age group and State, 70 to 79 percent of children participated in WIC sometime after their first birthday.

**Data completeness and quality.** Although the data acquisition and data linking processes went smoothly, there were limitations with the administrative data provided by each State. Because of these limitations, the study team had to incorporate additional sample restrictions when implementing the prenatal and children's analyses. These limitations have important implications for interpretation of findings from these analyses and for the feasibility of expanding WM-II to additional States.

In Missouri, the limitation was lack of data on Medicaid costs for Medicaid beneficiaries enrolled in managed care. One of the reasons Missouri was selected for WM-II was that its Medicaid program used both fee-for-service and managed care arrangements, depending on each beneficiary's county of residence. This distinction in Medicaid payment systems by location provided an opportunity to assess the challenges associated with measuring Medicaid costs under managed care. Ultimately, the study team found that the data required to estimate Medicaid costs were not available in managed care claims in Missouri. For this reason, it was not feasible to assess the association between WIC participation and Medicaid costs among the two-thirds of sample members in Missouri who were covered by managed care. However, it was possible to measure Medicaid costs among the one-third of fee-for-service beneficiaries in Missouri. In addition, it was possible to use both the managed care and fee-for-service claims in Missouri to construct a range of health care utilization measures for both the prenatal and children's analyses.

In Oklahoma, there were two data limitations. The first limitation was incomplete statewide data on WIC participation. One of the reasons Oklahoma was selected for WM-II was to provide insights into the feasibility of implementing WM-II in States where both a State agency and one or more independently operating ITOs provide WIC services. Ultimately, two of the nine ITOs operating in Oklahoma did not contribute WIC records to the study. The second limitation was lack of Medicaid claims data for Native Americans (17 percent of Medicaid-covered births and 19 percent of children). Oklahoma's Medicaid agency omitted these records because of concerns about incomplete and potentially missing claims from the Indian Health Service. Because of these limitations, analyses of associations between WIC participation and Medicaid costs and health care use in Oklahoma were limited to non-Native American WIC participants served by the State or one of the seven participating ITOs. Analyses of associations between prenatal WIC participation and outcomes measured in Vital Records data (in the prenatal analysis) were limited to WIC participants served by the Oklahoma State agency or one of the seven participating ITOs (including Native Americans).

**Conclusions.** The successful creation of the linked analytic databases for Missouri and Oklahoma demonstrated that it is feasible to collect data from State WIC, Medicaid, and Vital Records agencies and to link these data for individual women, infants, and children. Moreover, the availability of data collected in the 2003 U.S. Standard Birth Certificate allowed the study team to include a number of variables that were unavailable at the time WM-I data were collected. Thus, WM-II demonstrated that it was feasible to assess the relationship between prenatal WIC participation and an expanded set of pregnancy and birth outcomes and to enhance the approach used in WM-I by better controlling for differences between WIC participants and nonparticipants in the prenatal analysis.

WM-II encountered challenges in measuring Medicaid costs and assessing the association between WIC participation and Medicaid costs. Cost data were not available for all records in the linked data set, which limited the assessment of cost-related outcomes to a subset of the sample in both Missouri and Oklahoma. Cost data were available for Medicaid beneficiaries covered by fee-for-service arrangements, but not for beneficiaries covered by managed care arrangements. In Missouri, about two-thirds of the samples included in the prenatal and children's analyses were covered by managed care and about one-third were covered by fee-for-service. Consequently, Medicaid cost data were available for only about one-third of the prenatal and children's analysis samples in Missouri. In Oklahoma, all Medicaid beneficiaries were covered by fee-for-service, but Oklahoma did not provide Medicaid claims data for Native Americans. For this reason, data on Medicaid costs were available for 83 percent of the prenatal analysis sample in Oklahoma and 81 percent of the children's analysis sample.

It was not feasible to assess the association between WIC participation and Medicaid costs among the two-thirds of sample members in Missouri who were covered by managed care. It is likely that studies focused on Medicaid costs will continue to be difficult to conduct, given the increase in Medicaid managed care over the past few decades—in 2016, about 68 percent of all Medicaid beneficiaries were enrolled in a comprehensive managed care plan (Mathematica Policy Research 2018). However, State Medicaid agencies and the Centers for Medicare and Medicaid Services (CMS) are working to improve the quality of managed care encounter claims data, and some States now collect data on the costs paid by managed care plans to health care providers for managed care encounter claims. Thus, although WM-II was not able to assess the relationship between WIC participation and Medicaid costs among beneficiaries enrolled in managed care, future research might be able to examine the relationship between WIC participation and managed care plans' costs in select States. This option would be limited to States with more comprehensive managed care encounter records, or States where costs could be imputed.

Although Medicaid managed care claims may not provide data on Medicaid costs, they can be used to assess a broad range of health care utilization measures. Indeed, analyses that focus on *other* Medicaid outcomes—outcomes that can be measured for fee-for-service and managed care beneficiaries—are possible and could be an important area for future research. In particular, future studies of prenatal WIC participation would benefit from being expanded to include a wider array of measures related to maternal health, maternal behavior, and health care access and utilization. Examples include claims-based measures from the Center for Medicaid and CHIP Services' (CMCS') Core Set of Children's and Adult's Health Care Quality Measures (CMCS 2012, 2013). In addition, it is important to recognize that the presence of Medicaid managed care has no impact on the feasibility of assessing associations between WIC participation and birth outcomes or the other Vital Records-based outcomes examined in the WM-II prenatal analysis.

The experience of collecting data for Oklahoma demonstrates that expansion of WM-II to include States with ITOs might present special challenges. To obtain findings that are fully representative of all WIC participants in a given State, all ITOs operating in the State must contribute data to the study. Depending on the number of ITOs in the State and their internal connections, the task of obtaining complete data might be even more challenging than it was in WM-II. The seven ITOs in Oklahoma that provided data for WM-II used the same management information system—the Successful Partners in Reaching Innovative Technology (SPIRIT) system. This commonality greatly simplified the negotiation and data acquisition process relative to what would have been required to work with seven separate entities.

Similarly, the experience with Oklahoma demonstrates that expansion of WM-II to include States with large populations of Native Americans could present special challenges. Specifically, Medicaid claims submitted by the Indian Health Service to States' Medicaid agencies might be less complete than claims submitted by other providers.

WM-II intentionally focused on two carefully selected States. As designed, the study was not feasible in many States and the District of Columbia for one or more of the following reasons: (1) data from the revised birth certificate were unavailable for 2011 or earlier; (2) the comparison group would be very small because there were few Medicaid-eligible beneficiaries who did not participate in WIC; (3) the State had too few Medicaid-covered births for statistical precision; or (4) the State had a high rate of Medicaid managed care penetration, with few non-Medicaid managed care births per year (Kranker et al. 2013). Adjusting the existing study design along one or two of these dimensions and omitting the focus on Medicaid costs might render a study on outcomes measured in Vital Records and Medicaid data and associated with WIC participation feasible in more States. For example, if the study collected data for more than one year, it could include States with smaller Medicaid populations. Another option for obtaining the requisite sample sizes is to pool data from two or more States, although this approach would require moving away from State-specific estimates.

## C. Findings from the prenatal and children's analyses

Despite limitations that affected the representativeness of the analysis samples and the availability of data on Medicaid costs, FNS elected to move ahead with implementing the prenatal and children's analyses. Key findings from these analyses are summarized below. Because of the limitations described above and summarized in Table ES.1, these findings should be interpreted with caution. Although the results have high internal validity, the data limitations mean that results are not necessarily generalizable to the entire Medicaid populations in Missouri or Oklahoma, or to Medicaid populations in other States. The study team conducted a number of sensitivity analyses and robustness checks to shed light on the implications of the sample limitations. Key findings from these analyses are summarized in Chapters III and IV of this report and in technical appendices (provided in a separate volume).

**Table ES.1. Populations analyzed in WM-II, by type of outcome measure**

| State and subpopulations | Birth certificate outcomes | Medicaid health care utilization | Medicaid costs |
|---|---|---|---|
| **Missouri** | | | |
| - Fee-for-service | ✓ | ✓ | ✓ |
| - Managed care | ✓ | ✓ | |
| **Oklahoma**[a] | | | |
| - Non-Native Americans | ✓ | ✓ | ✓ |
| - Native Americans | ✓ | | |

[a] All analyses in Oklahoma were limited to mothers, infants, and children served by the Oklahoma State agency or one of the seven Indian Tribal Organizations that provided data for the study.

Both the prenatal and children's analyses compared outcomes for WIC participants and nonparticipants. For both analyses, the study team used administrative records from the WIC program to identify WIC participants. WIC participants were defined based on redemption of WIC food instruments rather than WIC certification. For the prenatal analysis, a woman was classified as a WIC participant if she redeemed at least one food instrument during the course of her pregnancy. For the children's analysis, a child was classified as a WIC participant if at least one food instrument was redeemed between his or her first birthday and the end of calendar year 2010. This approach to defining WIC participation differs from the regulatory definition, which includes all women and children who are issued food instruments, regardless of redemption. The advantage to using instrument redemption to identify WIC participants is that it excludes individuals who enrolled in WIC but never actually used any of the food benefits.

Because WIC participants might differ from nonparticipants in ways that influence study outcomes, WM-II researchers used inverse probability weighting (IPW) to match WIC participants and nonparticipants as closely as possible, thereby reducing the likelihood that underlying differences caused the estimated associations between WIC participation and the various outcomes. For most characteristics, differences between WIC participants and matched nonparticipants were small, and any observed differences were substantially reduced or eliminated after creating the matched comparison group of nonparticipants in each State. All analyses were run separately by State and, for the children's analysis, by age cohort. A number of sensitivity checks broadly demonstrated robustness of the results across plausible alternative methodologies, including when using alternative sets of matching variables in the IPW routine, alternative definitions of WIC participation, alternative sample inclusion or exclusion criteria, and alternative model specifications.

### 1. Findings from the prenatal analysis

The WM-II prenatal analysis was modeled on WM-I, which examined associations between prenatal WIC participation and birth outcomes and Medicaid costs from birth through 60 days postpartum. In addition to these outcomes, WM-II examined associations between prenatal WIC participation and (1) breastfeeding initiation (based on whether the infant was being breastfed at the time of discharge), (2) maternal weight gain during pregnancy, and (3) a second measure of Medicaid costs that included costs from the prenatal period through 60 days postpartum. Findings for these primary outcomes are discussed below and summarized in Table ES.2. The study team also analyzed a number of secondary outcomes and conducted supplemental analyses to examine associations by trimester of WIC enrollment, length of WIC participation, and among subgroups of women defined by mother's age and household income. Findings for these secondary outcomes and supplemental analyses are discussed in the body of the report, but are considered more exploratory because the analyses did not include the same level of statistical control used in the main analyses to minimize the potential for chance findings.

**Table ES.2. Estimates of the association between any prenatal WIC participation and the primary outcomes**

| | Missouri | | | Oklahoma[a] | | |
|---|---|---|---|---|---|---|
| Outcome | WIC | No WIC | Difference | WIC | No WIC | Difference |
| Breastfeeding at discharge (%) | 59.6 | 57.8 | 1.9** | 67.6 | 66.0 | 1.6* |
| **Maternal weight gain during pregnancy** | | | | | | |
| Lower than recommended (%) | 17.7 | 18.9 | -1.2 | 20.7 | 23.9 | -3.1** |
| Higher than recommended (%) | 47.3 | 45.3 | 2.0** | 42.2 | 39.8 | 2.4** |
| **Birth outcomes** | | | | | | |
| Low birthweight (%) | 7.4 | 7.7 | -0.3 | 7.0 | 7.6 | -0.6 |
| Very low birthweight (%) | 1.1 | 0.9 | 0.2 | 1.0 | 1.1 | -0.1 |
| Small-for-gestational age (%) | 11.2 | 10.9 | 0.4 | 10.7 | 11.2 | -0.5 |
| Neonatal infant mortality (deaths per 1,000) | 3.3 | 2.6 | 0.6 | 3.4 | 3.0 | 0.4 |
| **Medicaid costs[b]** | | | | | | |
| Birth through 60 days postpartum ($) | 6,676 | 7,256 | -580* | 5,692 | 5,638 | 54 |
| Prenatal period through 60 days postpartum ($) | 10,073 | 10,776 | -703* | 9,343 | 8,919 | 424** |

Source: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Note: Asterisks indicate statistically significant differences between WIC participants and nonparticipants at the $p < .01$ (**) and $p < .05$ (*) levels.

[a] All analyses in Oklahoma were limited to mothers and infants served by the Oklahoma State agency or one of the seven Indian Tribal Organizations that provided data for the study. Analyses of total Medicaid costs in Oklahoma are further restricted to non-Native Americans.

[b] Analysis of Medicaid costs in Missouri includes only fee-for-service beneficiaries.

g = grams; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

### a. Breastfeeding at discharge

Based on data from birth certificates, WIC participants in both Missouri and Oklahoma were more likely than nonparticipants to be breastfeeding their infants at the time they were discharged from the hospital (Table ES.2). Differences in the rates of breastfeeding were statistically significant, but relatively modest (59.6 versus 57.8 percent in Missouri and 67.6 versus 66.0 percent in Oklahoma).

### b. Maternal weight gain during pregnancy

The study team used information provided on the birth certificates (mothers' weight before pregnancy and at delivery) to calculate weight gain during pregnancy. The team then compared estimated weight gain to recommendations made by the Institute of Medicine (IOM)[1]—which take into account the mother's pre-pregnancy body mass index (BMI) (Rasmussen and Yaktine 2009)—and identified mothers whose pregnancy weight gain was more than 10 percent above or below recommended levels. In both Missouri and Oklahoma, WIC participants were more likely than nonparticipants to gain more weight than recommended by the IOM (Table ES.2). In Oklahoma, WIC participants were also less likely than nonparticipants to gain less weight than recommended by the IOM.

### c. Birth outcomes

WM-II examined associations between prenatal WIC participation and four primary birth outcomes—the prevalence of (1) low birthweight infants (less than 2,500 g), (2) very low birthweight infants (less than 1,500 g), (3) small-for-gestational-age infants (SGA), and (4) neonatal mortality (infant deaths occurring fewer than 28 days after birth). Estimates of associations between prenatal WIC participation and birth outcomes could be biased if the analysis does not account for the fact that women whose pregnancies last longer are less likely to experience an adverse birth outcome and, at the same time, have a longer opportunity to enroll in WIC. That is, women who begin to participate in WIC late in pregnancy tend to have better birth outcomes compared to women who enroll early simply because their pregnancies lasted longer (Devaney et al. 1992; Joyce et al. 2008). Because many prenatal WIC participants enroll in WIC later in their pregnancies, unadjusted analyses show that women who participate in WIC have, on average, better birth outcomes than women who never enroll in WIC. Researchers have used the term "gestational-age bias" to refer to the bias that results from this phenomenon.

Unadjusted descriptive statistics showed that, in the WM-II sample, adverse birth outcomes were more common among women who began participating in WIC in the first trimester than among women who did not participate until later in their pregnancies. Gestational-age bias needs to be eliminated to avoid interpreting these data to mean that early participation in WIC worsens birth outcomes. Not addressing gestational-age bias would almost certainly lead to overstated estimates of associations between WIC participation and adverse birth outcomes.

[1] The Institute of Medicine (IOM) is now referred to as the Health and Medicine Division of the National Academies of Science, Engineering, and Medicine (NASEM). Throughout this report, we refer to the IOM because that was the name of the organization when it developed the recommendations for prenatal weight gain referenced in this report.

In contrast to the main WM-I findings, which did not address the issue of gestational-age bias, WM-II used gestational age as a matching variable in IPW. Thus, the prenatal analysis was designed to compare prenatal WIC participants to a matched comparison group of nonparticipants with the same distribution of gestational age at delivery. So any differences in outcomes between prenatal WIC participants and nonparticipants cannot be attributed to differences in gestational age. However, differences in birth outcomes (and Medicaid costs) between WIC participants and matched nonparticipants might be attenuated if, in fact, WIC participation is associated with longer gestational lengths. The study team conducted several exploratory analyses to address this concern; findings from these analyses are discussed in the Summary and Conclusions section.

The overall prevalence of adverse birth outcomes was slightly lower or higher for WIC participants than for the matched nonparticipants, depending on the outcome and the State; however, the magnitudes of the differences were small, and none were statistically significant (Table ES.2). These findings are not consistent with the main findings from WM-I, which, without adjusting for gestational-age bias, found that prenatal WIC participation was associated with improved birth outcomes.

**d. Medicaid costs**

Findings for Medicaid costs differed across the two study States (Table ES.2). For Medicaid costs from birth through 60 days postpartum—the measure of Medicaid costs used in WM-I—prenatal WIC participation was associated with lower Medicaid costs among fee-for-service beneficiaries in Missouri, but there was no significant difference in Medicaid costs of WIC participants and nonparticipants in Oklahoma. The finding for Missouri is consistent with findings from WM-I, but the finding for Oklahoma is not.

When Medicaid costs for the prenatal period were included (so the outcome measured Medicaid costs from the prenatal period through 60 days postpartum), the finding for Missouri was unchanged—prenatal WIC participation was still associated with lower Medicaid costs among fee-for-service beneficiaries. In contrast, in Oklahoma, WIC participation was associated with higher Medicaid costs. The study team conducted several exploratory analyses to understand why associations between WIC participation and Medicaid costs might differ across the two study States and why Medicaid costs might be lower for WIC participants than for the matched nonparticipants in Missouri in the absence of significant associations between prenatal WIC participation and birth outcomes. Findings from these analyses are discussed below.

**e. Summary and conclusions**

In both Missouri and Oklahoma, prenatal WIC participation was associated with an increased prevalence of breastfeeding at the time of hospital discharge. This association was in the hypothesized direction and supplementary analysis found, plausibly, that the pattern was stronger among women who began participating in WIC earlier in their pregnancies. However, the finding differs from most prior research on the topic—only 1 of 13 studies reviewed by Colman et al. (2012) found a positive association between prenatal WIC participation and breastfeeding initiation. It is worth noting that the time frame for WM-II covers a period after the revised WIC food packages, including an enhanced food package for women who elect to breastfeed their babies, were implemented. This was not true for any of the studies reviewed in

Colman et al. (2012). Consequently, WM-II may provide evidence that the changes to the WIC food packages and related efforts by WIC agencies to promote and support breastfeeding could be having their intended effect. It is also possible that the differences in findings between WM-II and prior research are attributable to differences in data sources and/or analysis methods, particularly the definitions used to identify WIC participants and women who initiated breastfeeding and the carefully matched sample of nonparticipants.

In both Missouri and Oklahoma, prenatal WIC participation was associated with increased maternal weight gain during pregnancy. Specifically, WIC participants in both States were more likely than nonparticipants to have gained more than the recommended amount of weight and, in Oklahoma, WIC participants were less likely than nonparticipants to have gained less than the recommended amount of weight. These findings are consistent with findings from two prior studies that examined the association between WIC participation and weight gain during pregnancy (see Colman et al. 2012). Because more than half of all WIC participants in both Missouri and Oklahoma were overweight or obese at the start of their pregnancy, the association between WIC participation and higher-than-recommended weight gain can be viewed as a negative finding and may require additional attention from WIC policymakers. The findings that WIC participants in Oklahoma were less likely than nonparticipants to have lower-than-recommended weight gain is likely a positive finding—an indication that more WIC participants than nonparticipants are achieving the weight gain recommended by the IOM.

WM-II found no evidence—in either Missouri or Oklahoma—of an association between prenatal WIC participation and the primary birth outcomes examined in the prenatal analysis (low and very low birthweight, fetal growth, and neonatal infant mortality). More than 20 years ago, WM-I found that prenatal WIC participation was associated with “improved birth outcomes” (birthweight and gestational age). Exploratory analyses that isolated the potential influence of methodological differences between WM-I and WM-II indicated that the most important difference between the two studies was the use of analytic methods in WM-II that more credibly addressed gestational-age bias and, to a lesser extent, selection bias. This approach removed biases caused by the effect of gestational age on WIC participation, but also effectively eliminated the potential to measure impacts of WIC on birth outcomes that occur through the channel of increased gestational lengths. Associations between WIC participation and the study outcomes in WM-II would have been considerably larger—more similar to WM-I—if the WM-II specifications had not removed gestational-age bias. The results from WM-II are generally consistent with other recent studies that have found weak associations between prenatal WIC participation and fetal growth when adjusting for gestational-age bias (Colman et al 2012). However, secondary analyses using a hazard model revealed some differences between WIC participants and matched nonparticipants in the probability of delivering in certain stages of pregnancy, which implies the method of removing gestational-age bias may have been conservative and underestimated a potential association between WIC participation and other birth outcomes. More research is needed to assess the degree to which a causal association between WIC participation and gestational lengths might have attenuated the estimated associations between prenatal WIC participation and birth outcomes, but there is reason to believe that the WM-II results are less biased than results from an analysis that did not address gestational-age bias. Unadjusted analyses would almost certainly have overestimated the association between prenatal WIC participation and birth outcomes (and, by extension, Medicaid costs).

Among fee-for-service Medicaid beneficiaries in Missouri, prenatal WIC participation was associated with lower Medicaid costs—from birth through 60 days postpartum, as well as the prenatal period through 60 days postpartum. In Oklahoma, there was no significant difference between WIC participants and nonparticipants in Medicaid costs from birth through 60 days postpartum. However, when costs for the prenatal period were added, prenatal WIC participation was associated with *higher* Medicaid costs (for the prenatal period through 60 days postpartum). The association between prenatal WIC participation and Medicaid costs among fee-for-service beneficiaries in Missouri is consistent with findings from WM-I, but the findings in Oklahoma are not.

The study team conducted a variety of exploratory analyses to understand why associations between WIC participation and Medicaid costs might differ across the two study States and why Medicaid costs might be lower for WIC participants than for the matched nonparticipants in Missouri in the absence of significant associations between prenatal WIC participation and birth outcomes. (The lower Medicaid costs observed among WIC participants in WM-I were hypothesized to have been driven by improved birth outcomes.) These exploratory analyses showed that differences in the findings across States were driven by differences in the association between WIC participation and inpatient costs from birth through 60 days postpartum. In Oklahoma, Medicaid costs for inpatient (hospital) services were similar for WIC participants and the matched comparison group of nonparticipants—a finding that contrasts with findings from Missouri, but is consistent with the lack of association between prenatal WIC participation and birth outcomes. In Missouri, on the other hand, WIC mothers and their infants used fewer inpatient (hospital) services from birth though 60 days postpartum than the matched nonparticipants (especially for those in fee-for-service Medicaid, who were included in the cost analyses). This result was robust across a number of specification checks and robustness tests. Most notably, the infants of WIC participants in Missouri were admitted to the neonatal intensive care unit (NICU) at lower rates. The lower rates of NICU admission cannot be explained by differences in birth outcomes, differences in the hospitals where WIC participants give birth, regions of the State where WIC participants live, or the admission of infants with particular diagnoses into the NICU. Thus, an explanation remains elusive of how, exactly, WIC participation might lower infant NICU costs in Missouri through a channel other than birth outcomes.

For the measure of Medicaid costs that includes costs from the prenatal period, there were no differences between Missouri and Oklahoma in Medicaid costs for inpatient claims of WIC participants and matched nonparticipants in the prenatal period. However, differences were noted between the two States for mothers' non-inpatient costs during pregnancy. Overall, results from exploratory analyses suggest that the WIC program in both States connects women to prenatal care and other types of health care services during pregnancy. For example, exploratory analyses revealed strong associations in both States between WIC participation and increased rates of receiving adequate prenatal care and the number of Medicaid-paid office visits (although the magnitude of these associations varied somewhat between the States). In Oklahoma, these associations contributed to a large difference between WIC participants and nonparticipants in prenatal Medicaid costs. In Missouri, however, prenatal Medicaid costs were similar for WIC participants and nonparticipants. One potential explanation for the variation in findings across States is that prenatal WIC participants in Oklahoma had more (higher-cost) emergency room (ER) visits than nonparticipants. Another potential explanation is that many local WIC clinics in

Oklahoma (the places where women sign up for and receive WIC benefits) are located at county health clinics where WIC and Medicaid services are highly integrated. This integration, which is less common in Missouri, may connect women to prenatal care services, and might at least partially explain why outpatient Medicaid costs during the prenatal period for mothers in Oklahoma were higher for the WIC participants and the matched comparison group of nonparticipants (in comparison to Missouri). However, an alternate explanation—that pregnant women who are more connected to the health care system in general are also more likely to enroll in WIC—cannot be ruled out.

Some caution is warranted in interpreting these results. Selection bias remains a concern. Although IPW substantially reduced or eliminated any observed differences between WIC participants and nonparticipants on a number of important pre-pregnancy risk factors, the potential for selection bias cannot be completely ruled out. Even after balancing WIC participants and matched nonparticipants in terms of observable characteristics, it is possible that unobserved differences remain between the two groups. This retrospective observational study does not necessarily demonstrate a causal association between prenatal WIC participation and these outcomes. For example, differences in breastfeeding at discharge may reflect unobserved differences between women's characteristics, behaviors, or environments rather than the effects of WIC.

Another concern is that infants of prenatal WIC participants are enrolled in WIC at higher rates than infants of nonparticipants. Given that some WM-II outcomes were measured through the first 60 days after birth, it is likely the analysis did not actually disentangle the associations between those outcomes and *infant* WIC participation (in the first 60 days) from the associations with mother's *prenatal* WIC participation—that is, the results of the prenatal analysis are likely picking up effects of WIC participation in the infant's first 60 days. Because data on infants' WIC participation in the first 60 days were not collected, the study team could not assess the magnitude of these effects.

At a minimum, the WM-II prenatal analyses demonstrate the need for continued research on pregnant women and infants who participate in the ever-changing WIC and Medicaid programs. The prenatal analysis demonstrated some heterogeneity across the two study States and across subgroups within States in the associations between prenatal WIC participation and outcomes of interest. Future work, using data from additional States and potentially new research methods, could pursue a more complete understanding of the nature of this heterogeneity and the reasons WIC participation might or might not be associated with particular outcomes in particular States or with particular types of WIC participants.

Despite recognized data limitations, the WM-II prenatal analysis included important methodological advances relative to WM-I and informs future research in this area. These advances include enhanced methods to control for measured differences between WIC participants and nonparticipants; an expanded set of control variables; enhanced methods to remove gestational-age bias; an expanded set of outcomes, including maternal weight gain and breastfeeding at discharge; and a number of subgroup and sensitivity analyses.

### 2. Findings from the children's analysis

The WM-II children's analysis was modeled on the Buescher study, which assessed associations between child WIC participation and health care utilization (percentage of children with any well-child visits and percentage with any ER visits), diagnosis and treatment of common childhood illnesses, and total Medicaid costs in calendar year 2010. Separate analyses were conducted for cohorts of 1-, 2-, 3-, and 4-year-old children. Findings for these primary outcomes are discussed below and summarized in Table ES.3. The study team also analyzed a number of secondary outcomes and conducted supplemental analyses to examine associations by length of WIC participation and among subgroups of children defined by mother's age and household income. Findings for these secondary outcomes and supplemental analyses are discussed in the body of the report, but are considered more exploratory because the analyses did not include the same level of statistical control used in the main analyses to minimize the potential for chance findings.

**Table ES.3. Estimates of the association between any child WIC participation and the primary outcomes, by age cohort**

| | | Missouri | | | Oklahoma[a] | | |
|---|---|---|---|---|---|---|---|
| Outcome | Age cohort | WIC | No WIC | Difference | WIC | No WIC | Difference |
| **Health care utilization** | | | | | | | |
| Any well-child visits (%) | 1-year-olds | 72.6 | 57.5 | 15.1** | 70.7 | 61.7 | 9.0** |
| | 2-year-olds | 71.3 | 54.5 | 16.9** | 67.2 | 59.8 | 7.4** |
| | 3-year-olds | 70.9 | 54.4 | 16.5** | 68.4 | 62.6 | 5.8** |
| | 4-year-olds | 70.7 | 55.8 | 14.9** | 74.0 | 70.2 | 3.9** |
| Any ER visits (%) | 1-year-olds | 48.2 | 44.0 | 4.2** | 58.5 | 55.6 | 2.9** |
| | 2-year-olds | 41.4 | 37.8 | 3.6** | 50.9 | 46.9 | 4.0** |
| | 3-year-olds | 35.3 | 33.1 | 2.2* | 43.6 | 40.5 | 3.0** |
| | 4-year-olds | 31.4 | 27.6 | 3.9** | 40.2 | 36.4 | 3.9** |
| **Diagnosis and treatment of common childhood illnesses** | | | | | | | |
| Any visit for the diagnosis and treatment of a common childhood illness (%) | 1-year-olds | 85.1 | 78.6 | 6.6** | 86.2 | 83.4 | 2.8** |
| | 2-year-olds | 76.7 | 68.3 | 8.4** | 77.5 | 72.5 | 5.0** |
| | 3-year-olds | 70.6 | 63.8 | 6.8** | 71.5 | 67.5 | 4.1** |
| | 4-year-olds | 67.6 | 59.3 | 8.3** | 68.4 | 64.8 | 3.6** |
| **Medicaid costs[b,c]** | | | | | | | |
| Total Medicaid costs ($) | 1-year-olds | 2,495 | 2,277 | 219 | 2,165 | 2,198 | -33 |
| | 2-year-olds | 1,967 | 1,331 | 637** | 1,746 | 2,293 | -547* |
| | 3-year-olds | 1,784 | 2,001 | -217 | 1,725 | 1,921 | -196 |
| | 4-year-olds | 2,159 | 1,556 | 603* | 2,017 | 2,581 | -563 |

Source: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Asterisks indicate statistically significant differences between WIC participants and nonparticipants at the $p < .01$ (**) and $p < .05$ (*) levels.

Common childhood illnesses includes: otitis media (ear infection), upper respiratory infection, lower respiratory infection, asthma, iron deficiency anemia, gastroenteritis, or allergies.

[a] All analyses in Oklahoma were limited to non-Native Americans served by the Oklahoma State agency or one of the seven Indian Tribal Organizations that provided data for the study.

[b] Analysis of Medicaid costs in Missouri includes only fee-for-service beneficiaries.

[c] Sensitivity analyses indicated that findings for Medicaid costs, especially in Oklahoma, were not robust to alternative methodological approaches. For this reason, results presented in this table should be interpreted with caution. See Section D of the Executive Summary for more details.

ER = emergency room; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

### a. Health care utilization

In both Missouri and Oklahoma, child WIC participation was associated with increased health care utilization (Table ES.3). In both States and across age cohorts, children with any WIC participation were more likely than the matched nonparticipants to have had a well-child visit, and all the differences were statistically significant. Compared with nonparticipants, child WIC participants were 4 to 17 percentage points more likely to have had one or more well-child visits in calendar year 2010, depending on the State and age cohort. Children who participated in WIC were also more likely than nonparticipants to have visited the ER. Differences between WIC participants and nonparticipants were statistically significant for all four age cohorts in both States. Across States and age cohorts, WIC participants were 2 to 4 percentage points more likely than nonparticipants to have visited the ER. In both States, the proportion of children with at least one ER visit during calendar year 2010 decreased as age increased. Findings about the association between child WIC participation and health care utilization are consistent with findings from the Buescher study.

### b. Diagnosis and treatment of common childhood illnesses

Child WIC participation was associated with an increased probability of diagnosis and treatment of common childhood illnesses (Table ES.3). In both States and across age cohorts, children with any WIC participation were more likely than the matched nonparticipants to have received a diagnosis or treatment for one of six common childhood illnesses (otitis media [ear infection], upper respiratory infection, lower respiratory infection, asthma, iron deficiency anemia, gastroenteritis, or allergies). Across age cohorts and States, WIC participants were 3 to 8 percentage points more likely than nonparticipants to have received a diagnosis or treatment for common childhood illnesses. Findings about the association between child WIC participation and the diagnosis and treatment of common childhood illnesses are consistent with the Buescher study.

### c. Medicaid costs

Estimates of the association between child WIC participation and total Medicaid costs varied substantially by State. Among fee-for-service beneficiaries in Missouri, total Medicaid costs for calendar year 2010 were generally higher, on average, for child WIC participants than for matched nonparticipants, and this difference was statistically significant for the 2- and 4-year-old cohorts (Table ES.3). In Oklahoma, total Medicaid costs for calendar year 2010 were *lower*, on average, for WIC participants than nonparticipants, and this difference was statistically significant for only one cohort (2-year-olds). The pattern of findings for Missouri is consistent with findings from the Buescher study, which found that child WIC participation was associated with higher Medicaid costs, but the pattern of findings for Oklahoma is not consistent.

The study team conducted several supplementary analyses to explore potential explanations for the inconsistent finding in the two study States. As discussed in the next section, these supplementary analyses indicated that the association between child WIC participation and Medicaid costs in Oklahoma was sensitive to the treatment of outliers (particularly outliers with high inpatient Medicaid costs). Analyses that looked at the distribution of Medicaid costs showed that, across much of the distribution in both States, Medicaid costs were generally *higher* for WIC participants than for matched nonparticipants. Similarly, analyses that used the logarithm of costs found that Medicaid costs—in both States and for all four age cohorts—were significantly higher for WIC participants than for nonparticipants.

### d. Summary and conclusions

Findings from the children's analysis were mostly consistent with findings from the Buescher study, and indicate that child WIC participation in both Missouri and Oklahoma was associated with increased health care utilization and the increased diagnosis and treatment of common childhood illnesses. Moreover, as discussed below, exploratory analyses revealed that, in both Missouri and Oklahoma, *most* child WIC participants enrolled in fee-for-service Medicaid incurred higher Medicaid costs for these specific types of services compared with nonparticipants.

In Missouri, total Medicaid costs in 2010 were higher for WIC participants than nonparticipants, on average, and this difference was statistically significant for the 2- and 4-year-old cohorts. Exploratory analyses using disaggregated Medicaid claims data showed that costs for well-child visits, outpatient services, and prescription drugs were consistently higher for WIC participants than for nonparticipants, and these differences were statistically significant for three of the four age cohorts (all but 3-year-olds). There were no significant differences between WIC participants and nonparticipants in Missouri in costs for dental visits or inpatient hospital stays.

Findings for total Medicaid costs in Oklahoma differed from the findings for Missouri (and the Buescher study). Total Medicaid costs in Oklahoma were lower for WIC participants than for nonparticipants. Exploratory analyses using disaggregated Medicaid claims data revealed that this apparently anomalous finding was largely due to a small number of nonparticipant children in Oklahoma with high inpatient costs, which drove up the overall average cost for this group (that is, outliers in Medicaid costs had a strong influence on the results). Analysis with quantile treatment effect models and the logarithm of Medicaid costs found that WIC participation was associated with higher Medicaid costs for *most* children in Oklahoma, which is consistent with the findings for Missouri and with the Buescher study.

Considering all these findings together, WM-II findings were mostly consistent with findings from the Buescher study, and provide additional evidence that child WIC participants are better connected to the health care system than nonparticipants and, consequently, are more likely to use all kinds of health care services and more likely to be diagnosed and treated for common childhood illnesses. As the Buescher study pointed out, there is no reason to expect that the incidence of common childhood illnesses would be affected by WIC participation. Thus, the differences between WIC participants and nonparticipants on these outcomes raises concerns about undiagnosed and untreated illness among nonparticipant children. The higher prevalence of ER visits among WIC participants might suggest poorer access to appropriate clinic- and office-based care from primary care and other providers. However, some studies have found that interventions designed to increase access to health care services increase both physician office visits and ER visits, suggesting that the two types of services are complimentary (for example, see Finkelstein et al. 2016).

Some caution is warranted in interpreting these results. Selection bias remains a concern. Although IPW substantially reduced or eliminated any observed differences between WIC participants and nonparticipants, it is possible that unobserved differences remained between the two groups. This retrospective observational study does not necessarily demonstrate a causal association between child WIC participation and these outcomes. For example, differences in ER visits might reflect unobserved differences in health care needs rather than the effects of WIC.

Another concern is that most children who participate in WIC entered the program as infants (Castner et al. 2009). Because it is possible for prenatal and infant WIC participation to affect the outcomes in this study (in the same direction), it is likely the analysis did not actually disentangle the associations between child WIC participation from prenatal and infant WIC participation. A related concern is that children who remain on WIC after infancy could systematically differ from those who participated only as infants, leading to selection bias. Without data on mothers' prenatal WIC participation or children's participation in WIC as infants, the study team could not assess these differences.

Finally, it is worth noting that the results are estimates of the associations among child WIC participation and health care utilization, diagnosis and treatment of common childhood illnesses, and Medicaid costs in only one calendar year, as opposed to the entire time children might be enrolled in the Medicaid program. One could hypothesize that increased Medicaid expenditures in the first four years of life among WIC participants might still lead to cost savings in the long run if the underutilization of care in early childhood by non-WIC participants leads to more health problems later in life. WM-II did not collect the data required to examine this hypothesis; thus, future research is needed to examine the long-term health and economic benefits of WIC participation.

# I. INTRODUCTION

The mission of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is to safeguard the health of low-income women, infants, and children up to age 5 who are at nutritional risk. The program provides a combination of services, including nutritious foods to supplement diets, nutrition education, breastfeeding support, and referrals to health care and social services. WIC is the third largest of 15 nutrition assistance programs administered by the Food and Nutrition Service (FNS) in the U.S. Department of Agriculture (USDA). In fiscal year 2016, WIC served an average of about 8 million participants per month at a total annual cost of about $6 billion (Food and Nutrition Service 2017).

The WIC program has been widely studied. The existing body of research is large in size and scope and has been summarized in two comprehensive reviews (Fox et al. 2004; Colman et al. 2012).[2] In the late 1980s and early 1990s, researchers in several States linked administrative data from the WIC and Medicaid programs with birth certificate data to examine the relationship between prenatal WIC participation and birth outcomes and Medicaid costs. These studies, including the landmark WIC-Medicaid Study I (WM-I) funded by FNS, found that prenatal WIC participation was associated with improved birth outcomes and savings in Medicaid costs (Devaney et al. 1990, 1991a, 1991b, 1992; Devaney and Schirm 1993). Buescher et al. (2003) also analyzed linked WIC and Medicaid data, but focused on children ages 1 through 4. They found that children's WIC participation was associated with increased health care utilization and increased Medicaid costs, and concluded that WIC participation enhanced children's linkages to the health care system.

In the decades since these studies were conducted, much has changed in both the WIC and Medicaid programs. The WIC program has expanded dramatically. Waiting lists, common in the 1980s, are now non-existent. Today, nearly half of all infants in the United States and more than one-quarter of all pregnant women and children ages 1 through 4 participate in WIC (Oliveira and Frazao 2015). In addition, key characteristics of WIC participants have changed. For example, the proportion of participants identifying as Hispanic or Latino has increased dramatically—from 23 percent in 1992 to 42 percent in 2006 (Thorn et al. 2015)—and pregnant women are enrolling in WIC earlier in their pregnancies. Assuming comparable patterns of missing data over time, the percentage of prenatal WIC participants who enrolled in WIC during the first trimester of their pregnancies increased from 37 percent in 1992 to more than 50 percent in 2010 (Connor et al. 2011; Thorn et al. 2015).

In addition, there have been important changes in key policies of both the WIC and Medicaid programs since the earlier studies. The Child Nutrition and WIC Reauthorization Act of 1989 created adjunctive eligibility, which made low-income individuals who were receiving benefits from Medicaid, Temporary Assistance for Needy Families (TANF), or Supplemental

[2] The most recent comprehensive review (Colman et al. 2012) was completed as part of this study. Appendix A summarizes the key findings.

Nutrition Assistance Program (SNAP) automatically income-eligible for WIC.[3] Adjunctive eligibility has increased co-participation in WIC and Medicaid and increased income ceilings for WIC participation. Medicaid income-eligibility limits in all States are substantially higher than those in place at the time the previous WIC-Medicaid studies were conducted, and the Children's Health Insurance Program (CHIP) has expanded to cover pregnant women and children at higher levels of income. In 1999, WIC began using a standardized set of criteria to establish participants' nutritional risks. Before then, State agencies established their own nutritional risk criteria, and there was considerable variability across States. In addition, in 2009, WIC's supplemental food packages changed considerably, with the goal of improving participants' dietary patterns and increasing the prevalence and duration of breastfeeding.

The Medicaid program has also expanded dramatically since the 1980s and 1990s. Income-eligibility thresholds are substantially higher today, and States now have the discretion to use CHIP to extend health insurance to infants and children in families with incomes too high to qualify for Medicaid.[4] Medicaid and CHIP income thresholds for children now extend to at least 200 percent of the Federal poverty level (FPL) in most States and reach 300 percent and even higher in several States (Heberlein et al. 2012). Markus et al. (2013) estimated that Medicaid paid for 48 percent of all births in the United States in 2010. Another important change is the increasing prevalence of managed care in Medicaid and CHIP (Duggan and Hayford 2013). Under managed care, State Medicaid agencies contract with managed care plans to insure Medicaid beneficiaries for a negotiated capitated payment. Under this arrangement, the agencies do not always have access to detailed data about the costs associated with health care services provided to Medicaid beneficiaries that were covered by the managed care plan, although the scope and quality of Medicaid managed care data has improved over time. This improved scope and quality of data has important implications for efforts to update and expand analyses related to Medicaid costs, although measures of Medicaid-covered health care utilization are typically available.

Because of the changes that have occurred in the participation and policy environments of both WIC and Medicaid, FNS sought to update the previous studies. In 2010, FNS awarded a contract to Mathematica Policy Research to assess the feasibility of repeating and potentially expanding both WM-I and the Buescher et al. analysis (2003) (hereafter referred to as "the Buescher study"). This report presents findings from that study—the WIC-Medicaid II Study (WM-II). The rest of this chapter presents an overview of WM-II, including study objectives and research questions, procedures used to select States to participate in the study, and the general approach to the study. The chapter concludes with a description of the report's organization and content.

[3] At the time this legislation was passed, TANF was known as Aid for Families with Dependent Children (AFDC) and SNAP was known as the Food Stamp Program.

[4] For pregnant women, CHIP coverage is available only to those younger than 18 or residing in a State where CHIP covers pregnant women under unborn children provisions. Only Arkansas expands CHIP eligibility over 185 percent with the unborn children provision. Provisions of the Affordable Care Act have had a relatively small impact on the populations of interest for WM-II.

## A. Study objectives and research questions

The objective of WM-II was to assess the feasibility of repeating and potentially expanding analyses from WM-I and the Buescher study within current (2010) policy and participation environments. FNS specified the following research questions:

1. Can WM-I be replicated or can similar or improved methods be used to produce sufficiently reliable estimates of the association between prenatal WIC participation and birth outcomes and Medicaid costs within the post-partum period?
2. Can the Buescher study be replicated or can similar or improved methods be used to produce sufficiently reliable estimates of the association between child WIC participation and Medicaid costs and health care utilization?
3. Can reliable dose-response estimates of the associations between WIC participation and the outcomes above be produced?
4. Can reliable estimates of the associations between WIC participation [and the above outcomes] across strata of income and maternal age be produced?
5. What do the results of the feasibility assessment suggest about the potential for expanding WM-II to include other States?

FNS recognized that efforts to update the earlier research would encounter both opportunities and challenges. On the positive side, because of more liberal Medicaid income-eligibility requirements, updated analyses would not have to be limited to the very low-income populations included in the earlier research. In addition, advances in analytic methods and enhancements to the data available from birth certificates could lead to a more rigorous assessment of the association between WIC participation and health-related outcomes and Medicaid costs.

However, the increased participation in both WIC and Medicaid presented a potential challenge. The high rate of co-participation in the two programs could make it difficult to construct an adequate non-WIC comparison group. The increased prevalence of managed care in Medicaid presented an even greater challenge, and could make it difficult—if not impossible—to assess the impact of WIC participation on Medicaid costs. Recognizing these challenges, FNS limited the feasibility assessment to two States. If the knowledge gained from the feasibility assessment suggested that a rigorous assessment of the impacts of WIC participation was feasible, FNS had the option to expand the study to include five additional States.

## B. Approach to the study

The feasibility assessment focused on three overarching questions:

1. Can the administrative data required to update and expand the previous studies be obtained from two States?
2. Can these data be successfully linked to create the necessary analytic database for each State?

3. Can the analyses from WM-I and the Buescher study be updated or expanded by assessing additional outcomes, incorporating additional covariates, or using advanced analytic techniques?

The approaches used to address each of these questions are described below. Selection of the two study States was also an important consideration. Section C describes the process used to select the States.

### 1. Obtaining and linking administrative data

To update and expand WM-I and the Buescher study, the study team requested Statewide administrative data from three different agencies in each State:

- The study team asked the WIC agency to provide certification records and food voucher issuance and redemption records. These records were needed to identify WIC participants and nonparticipants and create WIC participation variables, including categorical or continuous measures of participation to use in dose-response models.
- The study team asked the Medicaid agency to provide eligibility records and Medicaid claims records. The eligibility records provided data on selected sociodemographic characteristics, and the claims records were used to measure Medicaid costs and, for replication of the Buescher study, health care utilization.
- The study team asked the Vital Records agency to provide birth, fetal death, and death certificates. The birth certificates provided an array of maternal, child, and household characteristics and were used to measure all outcomes other than Medicaid costs and health care utilization.

After obtaining the three administrative data sets, the study team linked records for specific individuals to create an analytic database that identified WIC participants and nonparticipants; measured the length and intensity of WIC participation; measured outcomes; and accounted for differences between WIC participants and nonparticipants in maternal, child, and household characteristics. In assessing the success of obtaining and linking the required administrative data and, therefore, the feasibility of expanding WM-II to additional States, the study team considered the completeness and quality of the data provided by States as well as the match rates achieved in creating the linked database.

### 2. Updating and expanding WM-I and the Buescher study

The study team designed and implemented two different analyses:

1. The **prenatal analysis** was modeled on WM-I and examined the association between WIC participation during pregnancy and birth outcomes, other health-related outcomes, and Medicaid costs through the first 60 days after birth.
2. The **children's analysis** was modeled on the Buescher study and examined the association between WIC participation during childhood and health care utilization, diagnosis and treatment of common childhood illnesses, and Medicaid costs.

The designs of both analyses aimed to update and expand the earlier studies by using current administrative data, examining a broader range of outcomes, and incorporating enhanced analysis methods. In addition, to facilitate comparisons between WM-I and WM-II, the prenatal analysis included supplemental analyses that replicated the WM-I approach as closely as possible using more recent administrative data.[5] To ensure that the analyses would capture potential impacts of changes to the WIC food packages implemented in 2009, the study used administrative data from 2010 for a period beginning six months after the new food packages were in place.

In interpreting results of these analyses, it is important to recognize that findings are not representative of the associations between WIC participation and the various outcomes nationwide. Moreover, because of limitations in the data provided by each study State (described in Chapter II), some State-level findings are only representative for subgroups of the State populations.

## C. Selecting two study States

Mathematica and FNS jointly selected the two States that participated in WM-II—Missouri and Oklahoma. They considered four main criteria in selecting these States:

1. **Availability of the revised 2003 birth certificate.** A key data source required to update or expand the earlier research was birth certificates. The U.S. Standard Birth Certificate was revised in 2003 to include a number of variables that were unavailable when WM-I was conducted. These revisions included the addition of variables that capture pregnancy-related risk factors, including previous adverse outcomes, smoking before pregnancy, inter-pregnancy interval, and pre-pregnancy body mass index (BMI). These variables are useful covariates for an analysis of the relationship between prenatal WIC participation and birth outcomes and Medicaid costs. Other newly introduced birth certificate variables enable the inclusion of several additional outcome measures in WM-II analyses, including maternal weight gain and breastfeeding at discharge.

   States were slow to implement the revised birth certificate, and some were still not using it when study States were selected in 2010. Both Missouri and Oklahoma implemented the revised birth certificate in 2010, so the enhanced data were available for the WM-II prenatal analysis.

2. **Income cutoffs of Medicaid and CHIP programs.** States can set their own eligibility and coverage rules for Medicaid and CHIP, as long as the rules comply with mandatory provisions in Federal law. Income thresholds may vary by population; many States employ more-generous income thresholds and related eligibility rules for pregnant women and infants than for older children and other populations.

   States selected to participate in WM-II had to have Medicaid income-eligibility thresholds for pregnant women, infants, and children that covered all WIC participants (so that everyone eligible for WIC was also eligible for Medicaid). For individuals who

[5] It was not necessary to conduct a separate replication of the Buescher study because there were fewer differences in the analytic approach, and findings from WM-II were largely consistent with the Buescher study.

are not adjunctively eligible, income eligibility for WIC is less than or equal to 185 percent of the FPL. In Missouri in 2010, the income threshold for Medicaid and CHIP was 185 percent of the FPL for pregnant women and 300 percent of the FPL for infants and children. In Oklahoma in 2010, the income threshold for Medicaid and CHIP was 185 percent of the FPL for pregnant women, infants, and children.

3. **Number of Medicaid-covered births.** Power calculations indicated the need for 20,000 Medicaid births, with a no-WIC comparison group comprising at least 20 percent of the total, to detect policy-relevant associations for dichotomous variables—for example, low birthweight and small-for-gestational-age (SGA) for the prenatal analysis, and the probability of receiving well-child visits for the children's analysis.[6]

   In selecting study States, the study team applied a criterion of at least 20,000 Medicaid-covered births per year. Publicly available data indicated that Missouri and Oklahoma had 31,326 and 33,898 Medicaid-covered births in 2009, respectively (National Governor's Association, Center for Best Practices 2010, 2011).

4. **Characteristics of Medicaid managed care programs.** In 2010, use of managed care programs in Medicaid and CHIP was widespread (Duggan and Hayford 2013).[7] At the time of WM-I and the Buescher study, fee-for-service arrangements were far more common than managed care. In fee-for-service arrangements, State Medicaid agencies pay providers based on detailed claims that document the services provided to participants and the associated costs. In managed care arrangements, States pay managed care organizations a set amount per participant that is not tied to specific services or claims. States vary in the requirements they place on managed care plans for submitting claims (known as encounter data) to document services provided to participants (Medicaid and CHIP Payment and Access Commission 2011). Thus, the prevalence of managed care in a State and the level of detail included in managed care encounter data had important implications for efforts to update and expand analyses related to Medicaid costs and health care use.

   To ensure that WM-II could successfully assess the challenges managed care data might present for assessing relationships between WIC participation and Medicaid costs, Mathematica and FNS decided to include one State that did not have Medicaid managed care (Oklahoma) and one State that had a mix of managed care and fee-for-service arrangements. Missouri filled this slot because, in 2011, about 45 percent of its Medicaid beneficiaries were covered by a managed care arrangement (Centers for Medicare and Medicaid Services [CMS] 2012). This meant that both fee-for-service and managed care claims would be available in Missouri. Importantly, county of residence—rather than individual characteristics of Medicaid beneficiaries—determined participation in

[6] Fewer observations are required to detect impacts on continuous variables such as Medicaid costs. Because the analysis included both dichotomous and continuous outcome variables, impact estimates for binary outcomes were the binding constraint for determining minimum sample size requirements. Sample sizes of 20,000 were also needed for the children's analysis, but this was not a binding constraint in States that met sample size requirements for the prenatal analysis.

[7] In this report, references to Medicaid managed care refer to capitated plans and exclude add-ons to the fee-for-service system, such as primary care case management.

managed care. Therefore, conditional on Medicaid beneficiaries' county of residence, unobserved characteristics would not affect whether Medicaid beneficiaries in Missouri were in fee-for-service or managed care.

Other factors considered in selecting Missouri and Oklahoma from an initial pool of States that met the inclusion criteria included the following: (1) willingness and ability of the Medicaid, WIC, and Vital Records agencies to participate in the study; (2) characteristics of the systems used to manage Medicaid, WIC, and Vital Records data; and (3) absence of ongoing or planned policy changes that might confound the study. In addition, FNS was interested in including Oklahoma because of the nine Indian Tribal Organizations (ITOs) that provide WIC services in that State. Including Oklahoma provided insights into the feasibility of implementing WM-II in States where both a State agency and one or more independently operating ITOs provide WIC services.

## D. Organization of the report

The report includes three additional chapters. Chapter II describes the methods used to obtain administrative data from the two study States, the procedures used to create the linked database, and conclusions about the feasibility of expanding WM-II to other States.[8] Chapters III and IV describe the approaches used in implementing the prenatal and children's analyses, respectively, and present findings for each of the study States. Technical appendices referenced in the chapters provide detailed summaries of various aspects of the study methodology as well as supplementary tables. These appendices are included in a separate volume.

[8] WM-II included a separate effort to assess the feasibility of implementing WM-II in other States. Findings are presented in detail in a separate report (Kranker et al. 2013).

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# II. COLLECTING AND LINKING ADMINISTRATIVE DATA

This chapter addresses two of the three overarching questions that WM-II was designed to answer: (1) whether the two study States (Missouri and Oklahoma) could provide the detailed administrative data needed to explore the associations between WIC participation and birth outcomes, Medicaid costs, and, for the children's analysis, healthcare utilization; and (2) whether these data could be successfully linked to create the necessary analytic database for each State.

To address these questions, the study team collected the required data from State agencies in Missouri and Oklahoma and linked data from the three sources to create an analytic database for each State. In assessing the success of these processes and, by extension, the feasibility of expanding WM-II to additional States, the study team considered the completeness and quality of the data provided by States and the match rates achieved in creating linked analytic databases.

## A. Defining the analysis samples

The first step in acquiring administrative data from Missouri and Oklahoma was to define the samples needed to replicate WM-I (prenatal analysis) and the Buescher study (children's analysis). The definition of analysis samples was driven primarily by the desire to examine WIC participants and nonparticipants at least six months after the 2009 revisions to the WIC food packages had been in place.

### 1. Prenatal analysis sample

The prenatal analysis examined Medicaid-covered births—that is, births for which Medicaid paid for the delivery or postpartum stay—during a 12-month period that began 6 months after the revised WIC food packages were implemented (October 2009 in Missouri and August 2009 in Oklahoma). Table II.1 summarizes the critical dates used to define the analysis samples for the prenatal analysis in each State.

**Table II.1. Key dates in the prenatal analysis**

| Milestone | | Missouri | Oklahoma |
|---|---|---|---|
| Revised WIC food packages were implemented | | October 2009 | August 2009 |
| Revised WIC food packages in place for 6 months | | March 2010 | January 2010 |
| Target 12-month period for the prenatal analysis sample | Infants' dates of birth | April 2010–March 2011 | February 2010–January 2011 |
| | Mothers' Medicaid claims | July 2009–May 2011 | May 2009–March 2011 |
| | Infants' Medicaid claims | April 2010–May 2011 | February 2010–March 2011 |
| | Infants' death certificates | April 2010–March 2012 | February 2010–January 2012 |

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

### 2. Children's analysis sample

The Buescher study followed a cohort of children in North Carolina from birth to age 5 and evaluated the effects of WIC participation through the first, second, third, and fourth years of life. The WM-II study team was not able to replicate the approach used in the Buescher study because the time line for WM-II did not allow for a longitudinal design. Instead, the WM-II design included a cross-section of children, ages 1 to 4 years, who were continuously enrolled in Medicaid during calendar year 2010.

After considering several options for identifying the sample, Mathematica and FNS elected to define cohorts of 1-, 2-, 3-, and 4-year-old children in a way that would allow for the analysis of Medicaid costs for a 12-month period for each child in the sample.[9] Table II.2 summarizes the critical dates used to define the analysis sample for the children's analysis. Children included in the sample were born from July 2005 to June 2009 and were grouped into age cohorts based on their age in June 2010—the midpoint of the year for which Medicaid claims data were collected.[10] For example, the cohort of 1-year-olds included children who were between the ages of 12 and 23 months in June 2010 (Figure II.1). Because children were 1 to 4 years old at the time of data collection, most children in the sample participated in WIC both before and after the 2009 changes to the WIC food packages (all but the youngest children in the 1-year-old cohort).

Because of the way in which the age cohorts were defined, the children in each cohort were not observed over a consistent age range. That is, outcomes were not uniformly measured from 12 to 24 months for all children in the 1-year-old cohort. For example, the oldest 1-year-olds (children born in July 2008) were ages 18 to 29 months in calendar year 2010, whereas the youngest 1-year-olds (children born in June 2009) were ages 7 to 18 months in calendar year 2010. About 75 percent of child-month observations were within the desired age range for each cohort. Because the number of months in which children were observed before they reached the age of 12 months was balanced by the number of months in which children were observed after they reached the age of 24 months, the mean and median age of children throughout the year was approximately 18 months. This age (18 months) is the midpoint between the children's first and second birthdays (12 and 24 months, respectively) and matches the longitudinal analysis in the Buescher study. In replicating the analyses of the Buescher study, the study team controlled for children's age to account for any potential differences in outcomes between older and younger children in the same cohort.

[9] An alternative approach was to construct birth cohorts such that all children within each cohort would have Medicaid claims measured for the same number of months and during the same ages. This approach was not optimal because outcomes would have been measured over seven months rather than a full year, making the results difficult to interpret or compare with other studies. In addition, the analysis would not have used about 70 percent of the data collected from States.

[10] For analyses pertaining to early, periodic screening, diagnosis, and treatment (EPSDT) visits, the study team limited the sample to children observed during the 3-month period around the recommended ages for EPSDT screening visits (at each of 15, 18, and 24 months). For example, the analytic sample for the 18-month EPSDT screening visit included children who were observed between the ages of 17 to 19 months at some time in calendar year 2010 (those born from July 2008 to June 2009), while the analytic sample for the 15-month EPSDT screening visit included children who were observed between the ages of 14 to 16 months at some time in calendar year 2010 (born from October 2008 to September 2009). Thus, the analytic sample for the EPSDT measures included some children born outside the date ranges shown in Table II.2. The EPSDT outcome measures are defined in Appendix G.

## Table II.2. Key dates in the children's analysis

| Milestone | | Dates |
|---|---|---|
| Revised WIC food packages were implemented | | Missouri: October 2009<br>Oklahoma: August 2009 |
| Revised WIC food packages in place for six months | | Missouri: March 2010<br>Oklahoma: January 2010 |
| Children's dates of birth | | July 2005–June 2009[a] |
| Children's claims | | January 2010–December 2010[b] |
| **Age cohorts** | | |
| 1-year-olds | Dates of birth | July 2008–June 2009[c] |
| | Potential months of WIC participation | July 2009–December 2010 |
| 2-year-olds | Dates of birth | July 2007–June 2008[c] |
| | Potential months of WIC participation | July 2008–December 2010 |
| 3-year-olds | Dates of birth | July 2006–June 2007[c] |
| | Potential months of WIC participation | July 2007–December 2010 |
| 4-year-olds | Dates of birth | July 2005–June 2006[c] |
| | Potential months of WIC participation | July 2006–December 2010 |

[a] Children with birth dates from July 2009 to September 2009 were not included in the main analyses, but were included in some analyses pertaining to EPSDT visits. See footnote 10 for details.

[b] All Medicaid claims for inpatient, outpatient, physician visits, ER, well-child, prescription drugs, dental services, and EPSDT care in calendar year 2010.

[c] The cohort of 1-year-olds included children ages 12 to 23 months in June 2010, the cohort of 2-year-olds included children ages 24 to 35 months in June 2010, the cohort of 3-year-olds included children ages 36 to 47 months in June 2010, and the cohort of 4-year-olds included children ages 48 to 59 months in June 2010. See Figure II.1.

EPSDT = early and periodic screening, diagnosis, and treatment; ER = emergency room; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

## Figure II.1. Definition of child WIC cohorts

| | | Age in months in 2010 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Birth Month | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
| 2009 | Dec | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | Nov | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| | Oct | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | Sep | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | Aug | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | July | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | June | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | May | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | April | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | March | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | Feb | 11 | 12 | 13 | 14 | Cohort of 1-year-olds | | | 18 | 19 | 20 | 21 | 22 |
| | Jan | 12 | 13 | 14 | 15 | | | | 19 | 20 | 21 | 22 | 23 |
| 2008 | Dec | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| | Nov | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| | Oct | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| | Sep | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| | Aug | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | July | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| | June | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | May | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| | April | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| | March | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| | Feb | 23 | 24 | 25 | 26 | Cohort of 2-year-olds | | | 30 | 31 | 32 | 33 | 34 |
| | Jan | 24 | 25 | 26 | 27 | | | | 31 | 32 | 33 | 34 | 35 |
| 2007 | Dec | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| | Nov | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| | Oct | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
| | Sep | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| | Aug | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| | July | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
| | June | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
| | May | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
| | April | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| | March | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| | Feb | 35 | 36 | 37 | 38 | Cohort of 3-year-olds | | | 42 | 43 | 44 | 45 | 46 |
| | Jan | 36 | 37 | 38 | 39 | | | | 43 | 44 | 45 | 46 | 47 |
| 2006 | Dec | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| | Nov | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| | Oct | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| | Sep | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
| | Aug | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 |
| | July | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 |
| | June | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 |
| | May | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 |
| | April | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| | March | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 |
| | Feb | 47 | 48 | 49 | 50 | Cohort of 4-year-olds | | | 54 | 55 | 56 | 57 | 58 |
| | Jan | 48 | 49 | 50 | 51 | | | | 55 | 56 | 57 | 58 | 59 |
| 2005 | Dec | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| | Nov | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
| | Oct | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 |
| | Sep | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| | Aug | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| | July | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 |
| | June | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 |
| | May | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 |
| | April | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 |
| | March | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 |
| | Feb | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |

Note: The cells in the figure highlighted in blue identify cohorts of children included in the main analysis. The analysis of EPSDT compliance used a different cohort definition. Details are provided in footnote 10 and Chapter IV.

EPSDT = early and periodic screening, diagnosis, and treatment; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

## B. Obtaining administrative data

The study team collected administrative data files from WIC, Medicaid, and Vital Records agencies in Missouri and Oklahoma. Each State provided the following files:

- **WIC agency**[11]
  - Certification records
  - Food voucher issuance and redemption records
- **Medicaid agency**
  - Enrollment records
  - Claims records
- **Vital Records agency**
  - Birth certificates
  - Fetal death certificates
  - Death certificates

These data files data were collected for a variety of analytical purposes. The study team used the Medicaid enrollment records and the birth certificate data to identify individuals who met the inclusion criteria for the analysis samples (see Tables II.1 and II.2). In addition, the study team used the administrative data files to construct outcome measures and control variables needed to replicate and expand the analyses conducted in WM-I and the Buescher study. For example, the study team used WIC certification and voucher issuance and redemption records to identify WIC participants and nonparticipants and used voucher issuance and redemption records to measure the length and intensity of WIC participation. The Medicaid claims records provided data on Medicaid costs and health care utilization, and the Vital Records files provided information on the prevalence of low birthweight infants, neonatal mortality rates, breastfeeding initiation, and maternal weight gain. Medicaid enrollment records and birth certificates provided data on sociodemographic and other characteristics needed to control for differences between WIC participants and nonparticipants in estimating associations between WIC participation and the outcomes of interest. Each of these files also contained variables that were used for the sole purpose of linking records for the same individual across files.

The study team executed data usage agreements with each State agency and obtained required institutional review board (IRB) approvals. Following IRB approval, the study team submitted detailed data requests to each agency. The data requests identified (separately for the prenatal analysis and the children's analysis) the time frame for the data extracts and the specific data elements requested. Table II.3 provides an overview of the data requested from each State. Appendix B and Chapters III and IV describe the data collected in more detail.

[11] In Oklahoma, WIC records were requested from the State agency as well as the nine ITOs that provide WIC services in Oklahoma.

**Table II.3. Overview of data collected for WM-II: data sources, analysis samples, purpose, and data elements**

| | WIC certification records | WIC voucher records | Medicaid enrollment records | Medicaid claims | Vital Records birth certificates | Vital Records fetal death certificates | Vital Records death certificates |
|---|---|---|---|---|---|---|---|
| **Data source** | | | | | | | |
| State agency | WIC | WIC | Medicaid | Medicaid | Vital Records | Vital Records | Vital Records |
| **Analysis sample(s)** | | | | | | | |
| Mothers in prenatal analysis | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Infants in prenatal analysis | ✓ | | ✓ | ✓ | ✓ | | ✓ |
| Children in children's analysis | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| **Primary purpose(s)** | | | | | | | |
| Identify individuals meeting analysis sample inclusion criteria | | | ✓ | ✓ | ✓ | ✓ | |
| Measure outcomes | | | ✓ | ✓ | ✓ | | ✓ |
| Construct covariates | | | ✓ | ✓ | ✓ | | |
| Identify WIC participants and nonparticipants | ✓ | ✓ | | | | | |
| Measure length/intensity of WIC participation | | ✓ | | | | | |
| Data elements for linking | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Example data elements** | | | | | | | |
| For constructing analysis variables | WIC certification date | Dates of voucher issuance and redemption, status code, amount paid | Dates of Medicaid enrollment, eligibility category, managed care enrollment, family income, SNAP and TANF receipt | Diagnoses, procedures, amount paid, service dates, provider | Demographics, education, risk factors, DOB, birth history, prenatal care, smoking, mother's weight, birth weight, gestation, plurality | n.a. | Date of death |
| For data linking | Name, DOB, date of delivery, WIC ID and household ID, Medicaid ID, SSN, address, telephone number, demographics | WIC ID | Name, Medicaid ID and household ID, SSN, address, DOB, telephone number, demographics | Medicaid ID, provider, service dates | Names, mother's SSN, DOB, address, facility name, received WIC (self-reported), demographics | Names, mother's SSN, DOB, date of fetal death, address, facility name | Name, DOB, SSN, address |

Notes: Appendix B provides a full list of data sources and elements requested from each State, and describes the data linking process, Chapters III and IV discuss the data elements requested for the prenatal analysis and the children's analysis, respectively.

DOB = date of birth; ID = identification number; n.a. = not applicable; SNAP = Supplemental Nutrition Assistance Program; SSN = Social Security number; TANF = Temporary Assistance for Needy Families; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

## C. Creating the linked analytic databases

After obtaining the administrative data from WIC, Medicaid, and Vital Records agencies in each State, the study team linked records across the seven types of files to create two separate analytic databases for each State—one to support the prenatal analysis and one to support the children's analysis. In constructing these analytic databases, the study team first linked Medicaid records and Vital Records data to identify analytic samples, measure outcomes, and construct covariates. Then they matched the resulting file to the WIC certification records and to the WIC voucher issuance and redemption records to identify WIC participants and nonparticipants and measure the duration and intensity of WIC participation among participants.

The process of linking administrative data files was analytically and technically challenging, as well as resource-intensive. The sections that follow discuss the results of the data linkage process for the prenatal analysis and the children's analysis, respectively. Four separate linked databases were constructed—in each of the two study States, one linked database was constructed to support the prenatal analysis and another was constructed to support the children's analysis. For simplicity, the text generally refers to each type of linked database in the singular (that is, the linked database for the prenatal analysis and the linked database for the children's analysis). Appendix B provides a detailed description of the process used to create the linked databases, including a description of the files, how the files were prepared, and the methods and variables used for linking.

### 1. Database for the prenatal analysis

The linked database for the prenatal analysis included mother-infant dyads for which Medicaid paid for the delivery or postpartum stay. Dyads that included a multiple birth (that is, twins, triplets, and quadruplets), a fetal death, or were missing data on gestational age were excluded. Restriction to singleton births is common in studies examining birth outcomes. In general, multiple births are at higher risk of adverse birth outcomes, but WIC participation does not affect plurality. Thus, excluding multiple births reduces the potential that results could be biased by mis-specification of the econometric models.[12] Fetal deaths were removed because one of the primary hypotheses tested in the prenatal analysis is that prenatal WIC participation is associated with lower Medicaid costs; fetal deaths could confound this analysis because they might be associated with lower Medicaid costs. The singleton birth criterion excluded 1,269 births in Missouri and 923 in Oklahoma, and the fetal death criterion excluded 14 infants in Missouri and 18 in Oklahoma. Births missing gestational age—252 births in Missouri (0.7 percent) and 171 births in Oklahoma (0.6 percent)—were removed from the sample because gestational age is required to estimate the date of conception for a mother's pregnancy, which, in turn, is used to calculate the length of WIC participation.

In creating the linked database for the prenatal analysis, the study team achieved high match rates for both Missouri and Oklahoma. Table II.4 presents summary data on the numbers of Medicaid-covered mothers and newborns in each State and the percentages matched successfully across the WIC, Medicaid, and Vital Records data sets. As shown, match rates were 97 to 99

[12] Sensitivity analyses summarized in Chapter III demonstrate that results of the prenatal analysis were similar when multiple births were included.

percent in both States—equivalent to or higher than the match rates achieved in the five States included in WM-I. These match rates likely approach the upper bound possible because birth certificate data were not collected for out-of-State births covered by the Medicaid agencies in each State.[13] Medicaid beneficiaries who did not match to a birth certificate and, therefore, were not included in the linked database were similar to beneficiaries who were matched to a birth certificate.[14]

In the end, the linked database for the prenatal analysis in Missouri included 37,837 mother-infant dyads, and the linked database for Oklahoma included 30,682 mother-infant dyads (Table II.4). The total sample size of Medicaid births included in the WM-II analysis in each State was larger than the samples used for four of the five States included in WM-I and, for three of the four States, the magnitude of the difference was substantial. In addition, the percentage of women who participated in WIC during their pregnancy was higher in Missouri and Oklahoma than in four of the States that participated in WM-I (bottom panel of Table II.4).

The linked databases—one for each of the two States included in the study—include three different types of Medicaid-covered births: (1) a birth for which Medicaid covered both the mother and the infant; (2) a birth for which Medicaid covered the mother, but not the infant; and (3) a birth for which Medicaid covered the infant, but not the mother. Medicaid does not always pay for both the mother's delivery and the infant's birth—the mother or infant might not have been eligible for Medicaid, might not have applied for Medicaid, or might have been enrolled in Medicaid but did not have Medicaid claims that included procedure codes indicating birth or delivery. There might also have been cases in which the linking process failed to link mother's and infant's records.

Consistent with WM-I, the linked database and the ultimate analysis included all three types of Medicaid-covered births. Data linkage was possible for all three types of births because the Vital Records contained personal identifiers (such as names and dates of birth) for both the mother and the infant, which could be used to link Vital Records with Medicaid and WIC data. As demonstrated in Table II.5, the vast majority of cases (96 percent in Missouri and 87 percent in Oklahoma) were fully covered mother-infant dyads; robustness checks described in Chapter III indicated that results were similar when the analysis sample was limited to just these cases.

[13] Cross-State Vital Records Agency agreements generally preclude States from sharing birth certificates for citizens of other States.

[14] Differences between the two groups were generally less than 0.25 of a standard deviation on mother and infant characteristics available in the Medicaid files (in both States). The major exception is that birth certificates were less likely to be matched to the Medicaid files if the Medicaid data contained data for only the infant or only the mother (but not both), which was expected, given that fewer linking variables were available for these mothers or infants.

## Table II.4. Numbers and percentages of Medicaid mothers and newborns included in linked database for the prenatal analysis: Missouri, Oklahoma, and WIC-Medicaid I

| | WM-II | | WM-I | | | | |
|---|---|---|---|---|---|---|---|
| | Missouri | Oklahoma | Florida | Minnesota | North Carolina | South Carolina | Texas |
| **All Medicaid mothers** | 37,996 | 30,630 | 32,967 | 10,842 | 19,721 | 11,671 | 24,475 |
| Medicaid mothers included in database | 37,019 | 29,923 | 32,033 | 10,450 | 18,501 | 10,462 | 23,534 |
| Percentage of all Medicaid mothers included in database | 97.4 | 97.7 | 97.1 | 96.4 | 93.8 | 89.6 | 96.2 |
| **All Medicaid newborns** | 38,276 | 28,044 | 26,662 | 10,313 | 18,450 | 12,781 | 25,767 |
| Medicaid newborns included in database | 37,249 | 27,305 | 25,873 | 10,153 | 18,091 | 11,358 | 25,097 |
| Percentage of all Medicaid newborns included in database | 97.3 | 97.4 | 97.0 | 98.5 | 98.1 | 88.9 | 97.4 |
| **All Medicaid dyads (mothers linked to newborns)** | 36,943 | 27,064 | NR | NR | NR | NR | NR |
| Medicaid dyads included in database | 36,431 | 26,546 | NR | NR | NR | NR | NR |
| Percentage of all Medicaid dyads included in database | 98.6 | 98.1 | NR | NR | NR | NR | NR |
| **Total Medicaid births included in the database (Medicaid mothers and/or infants)** | 37,837 | 30,682 | 35,558 | 11,592 | 20,441 | 11,641 | 25,472 |
| Births to WIC participants | 26,703 | 22,537 | 20,476 | 7,977 | 14,039 | 8,543 | 12.18 |
| Births to nonparticipants | 11,134 | 8,145 | 15,082 | 3,615 | 6,402 | 3,098 | 13,392 |
| Percentage of births to WIC participants | 70.6 | 73.5 | 57.6 | 68.8 | 68.7 | 73.4 | 47.8 |

Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research, and Devaney et al. (1990), Tables III.1 and III.2.

Notes: In the first three panels, the first row presents the number of Medicaid-covered mothers and/or newborns who met the inclusion criteria described in Section II.C.1. The next two rows present the number and percentage of these observations that were matched to a birth certificate and, therefore, included in the linked database. The three panels distinguish among cases in which Medicaid paid for the delivery for the mother (first panel), paid for the birth of the infant (second panel), or paid for both the mother and the infant (third panel). The fourth panel presents the final number of mothers and infants included in the linked database, including observations in which the mother's or infant's Medicaid records were linked to a birth certificate (but not necessarily both the mother and the infant).

As discussed in Section II.D, because of limitations in the data provided by the study States, sample sizes for some analyses were smaller than the samples sizes shown in this table.

NR = not reported; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-I = WIC-Medicaid Study I; WM-II = WIC-Medicaid II Feasibility Study.

**Table II.5. Distribution of Medicaid coverage among births included in the linked database for the prenatal analysis**

| | Missouri | | Oklahoma | |
|---|---|---|---|---|
| **Type of Medicaid coverage** | **Number of Medicaid births in database** | **Percentage of Medicaid births in database** | **Number of Medicaid births in database** | **Percentage of Medicaid births in database** |
| Medicaid covered both mother and infant | 36,431 | 96.3 | 26,546 | 86.5 |
| Medicaid covered mother only | 588 | 1.6 | 3,377 | 11.0 |
| Medicaid covered infant only | 818 | 2.2 | 759 | 2.5 |
| **Total** | **37,837** | **100** | **30,682** | **100** |

Source: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Type of Medicaid coverage based on the linked WM-II database. The table distinguishes among cases in which a birth certificate was linked to Medicaid data for both a mother and an infant (first row), for a mother only (second row), or for an infant only (third row) The fourth row (Total) shows the final number of Medicaid-paid births included in the linked database, including observations in which the mother's or infant's Medicaid records were linked to a birth certificate (but not necessarily both the mother and the infant). Percentages may not total to 100 percent due to rounding.

WM-II = WIC-Medicaid II Feasibility Study.

## 2. Database for children's analysis

As described in Section II.A.2, children eligible for inclusion in the children's analysis were born from June 2005 to December 2009 and were continuously enrolled in Medicaid in calendar year 2010. Among eligible children, the study team achieved high match rates in both Missouri and Oklahoma when linking WIC, Medicaid, and Vital Records. Table II.6 presents summary data on the numbers of age-eligible Medicaid children in Missouri, Oklahoma, and the Buescher study included in the linked database, and the percentage of these children who were successfully matched across administrative data sets. As shown, the analysis included 88 percent of age-eligible Medicaid children in Missouri and 85 percent of age-eligible Medicaid children in Oklahoma. These results exceed the 77 percent of age-eligible Medicaid children included in the Buescher study. Compared to the Buescher study, the analysis sample for Missouri was larger and the analysis sample for Oklahoma was smaller.

In Missouri and Oklahoma, respectively, 153,259 and 113,245 children ages 1 to 4 years in 2010 participated in WIC at some time after their first birthday. However, the linked database included only 55 and 42 percent of these children, respectively. Many WIC participants were excluded from the analysis because they were not enrolled in Medicaid in 2010 or were enrolled for fewer than 12 months.[15] This happened more often for the older children.

[15] Following the Buescher study, WM-II required continuous enrollment in Medicaid. Continuous enrollment translated to at least one day in each of the 12 months in calendar year 2010. Loosening this criterion to include children with at least 10 months of enrollment would have increased the sample sizes by 5 percent in Missouri and 9 percent in Oklahoma.

### Table II.6. Numbers of Medicaid children included in the children's analysis and percentages participating in WIC: Missouri, Oklahoma, and the Buescher study

| | WIC-Medicaid II | | Buescher study |
|---|---|---|---|
| | Missouri | Oklahoma | North Carolina |
| **Percentage of age-eligible Medicaid children included in analysis** | 88.0 | 84.7 | 77 |
| **Total Medicaid-enrolled children included in analysis** | 110,198 | 63,297 | 73,283 |
| 1-year-olds | 29,891 | 17,291 | 21,277 |
| 2-year-olds | 28,465 | 15,974 | 18,750 |
| 3-year-olds | 27,032 | 15,780 | 16,931 |
| 4-year-olds | 24,810 | 14,252 | 16,325 |
| **Total WIC children included in analysis** | 83,762 | 47,381 | 58,606 |
| 1-year-olds | 21,295 | 12,116 | 15,992 |
| 2-year-olds | 21,833 | 12,066 | 14,849 |
| 3-year-olds | 21,243 | 12,152 | 13,987 |
| 4-year-olds | 19,391 | 11,047 | 13,778 |
| **Total non-WIC children included in analysis** | 26,436 | 15,916 | 14,677 |
| 1-year-olds | 8,596 | 5,175 | 5,285 |
| 2-year-olds | 6,632 | 3,908 | 3,901 |
| 3-year-olds | 5,789 | 3,628 | 2,944 |
| 4-year-olds | 5,419 | 3,205 | 2,547 |
| **Percentage of children included in analysis participating in WIC** | 76.0 | 74.9 | 80.0 |
| 1-year-olds | 71.2 | 70.1 | 75.2 |
| 2-year-olds | 76.7 | 75.5 | 79.2 |
| 3-year-olds | 78.6 | 77.0 | 82.6 |
| 4-year-olds | 78.2 | 77.5 | 84.4 |

Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research, and Buescher et al. (2003).

Notes: As discussed in Section II.D, limitations in data provided by study States resulted in sample sizes for some analyses being smaller than the samples sizes shown in this table.

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

## D. Data completeness and quality

Overall, the data acquisition and data linking processes went smoothly. However, as discussed in this section, there were limitations with the administrative data provided by each State. Because of these limitations, the study team had to incorporate additional sample restrictions when implementing the prenatal and children's analyses. These limitations have important implications for interpretation of findings from these analyses (summarized in Chapters III and IV) and for the feasibility of expanding WM-II to additional States.

### 1. WIC certification and voucher records

The completeness and quality of the WIC records provided by Missouri was high and it was relatively straightforward to use these data to identify WIC participants and, among WIC participants, to measure the timing and intensity of participation. However, there was an important limitation in the WIC records obtained for Oklahoma. As discussed in Chapter I, one of the reasons Oklahoma was selected to participate in the study was to provide insights into the feasibility of implementing WM-II in States where both a State agency and one or more independently operating ITOs provide WIC services. To obtain information for all prenatal and child WIC participants, the study team had to collect administrative data from the State agency and from nine ITOs that operate independent WIC programs in Oklahoma. Ultimately, two of the nine ITOs did not contribute WIC records to the study (hereafter, these ITOs are referred to as non-reporting ITOs).

The lack of WIC records from two non-reporting ITOs was an obstacle to identifying WIC participants in Oklahoma. The services provided by these ITOs were not restricted to members of a specific tribe or to Native Americans in general. Combined, the two non-reporting ITOs served about 1,200 pregnant women and 5,800 children in 2010 (Connor et al. 2011). The study team could not assume that sample members not represented in the WIC administrative data provided by the State and seven ITOs did not participate in WIC; these sample members may have participated in WIC through one of the two non-reporting ITOs. Ignoring this possibility and misclassifying women and children who actually participated in WIC would have biased estimates toward zero (that is, toward not finding an association between WIC participation and the study outcomes).

To address this situation, the study team used information about families' proximity to WIC clinics operated by the two nonparticipating ITOs and information from birth certificates about self-reported participation in WIC (when applicable) to identify and exclude from the WM-II analysis samples those likely to have participated in WIC through a nonparticipating ITO. Appendix C presents details and results of this methodological approach. In the end, the study team excluded 1,070 pregnant women (3.4 percent of the full sample) in Oklahoma from the prenatal analysis. Similarly, the children's analysis sample excluded children who were likely to have participated in WIC through one of the non-reporting ITOs. Compared with the number of exclusions for the prenatal analysis, a larger proportion of the full sample was excluded from the children's analysis. In the prenatal analysis, the study team was able to leverage information about mother's self-reported prenatal WIC participation from the WIC birth certificate. Comparable data were not available for the children.

The implication of this data limitation is that all findings from the prenatal and children's analyses for Oklahoma generalize only to WIC participants who participated through the State or one of the seven reporting ITOs. Moreover, some potential for misclassification of WIC participants remains, even after making the adjustments discussed in the preceding section. Reported findings on the association between WIC participation and the outcomes of interest are conservative if such misclassification exists. This potential misclassification is unlikely a major concern for the prenatal analysis. Robustness checks discussed in Chapter III revealed that the main findings for the prenatal analysis were robust for two sensitivity tests—one that retained all excluded cases and considered them to be nonparticipants, and another that retained all excluded cases and considered them to be WIC participants. However, robustness checks for the children's analysis, discussed in Chapter IV, did not clarify whether estimates of the association between WIC participation and the study outcomes would have differed if the analysis sample could have included the full sample of WIC children in Oklahoma—that is, if all nine ITOs had contributed data on WIC participation.

### 2. Medicaid enrollment records and claims

Both Missouri and Oklahoma provided Medicaid enrollment records that were complete and of high quality. However, there were major limitations with the Medicaid claims data from both States. As described in Chapter I, Missouri was selected to participate in the study because its Medicaid program provided benefits through either managed care or fee-for-service arrangements, depending on a beneficiary's county of residence. This condition provided an opportunity to assess the challenges managed care data might present for assessing relationships between WIC participation and Medicaid costs.

It is incongruous to include the cost of medical encounter claims in the WM-II cost measures, given that managed care plans, not Missouri HealthNet (the State's Medicaid agency), pay providers for these services.[16] The study team explored the possibility of estimating the relationship between WIC participation and the costs paid by managed care plans, but the data required to estimate the association were unavailable in the WM-II database. Examination of the encounter claims submitted by Medicaid managed care plans to Missouri HealthNet revealed that the "paid amount" field tended to be filled in for some types of claims but not for others. Although most medical encounter claims included data on paid amounts, inpatient claims rarely included these data, and the availability of these data varied widely in encounter claims for outpatient services.[17]

Because appropriate cost data were not available for health care services received by Medicaid beneficiaries served by managed care plans, the assessment of the association between WIC participation and Medicaid costs in Missouri was limited to Medicaid beneficiaries who received benefits through fee-for-service arrangements only. This population of beneficiaries

[16] Missouri's Medicaid program incurs costs for its managed care beneficiaries in the form of a fixed amount per beneficiary, which the Medicaid program pays to managed care plans regardless of actual service utilization. There is no reason to expect costs to Missouri's Medicaid program to vary between WIC participants and similar nonparticipant managed care beneficiaries—even if health care use differs between the two groups.

[17] Medical encounter claims include physician office visits and many other types of care.

includes about 36 percent of the full analysis sample in the prenatal analysis and 32 percent of the full sample in the children's analysis.[18] Consequently, findings about the associations between WIC participation and Medicaid costs in Missouri generalize only to Medicaid beneficiaries who participated in the fee-for-service program.[19] Findings for other outcomes in Missouri are not subject to this limitation because those analyses include Medicaid beneficiaries in both fee-for-service and managed care.[20]

Oklahoma was selected to participate in the study because its Medicaid program did not use managed care arrangements. In theory, this arrangement guaranteed that the data needed to assess the association between WIC participation and Medicaid costs and health care utilization would be available. However, the study team faced a different type of challenge in using Medicaid data to create the analytic databases for the prenatal and children's analyses in Oklahoma. Oklahoma's Medicaid agency did not provide Medicaid claims for Native Americans (17 percent of all mother-infant dyads and 19 percent of children). The agency omitted these records because of concerns about incomplete and potentially missing claims from the Indian Health Service. This limitation means that findings about associations between WIC participation and Medicaid costs and health care use in Oklahoma are generalizable only to non-Native American WIC participants served by the State or one of the participating ITOs. Oklahoma did include Native Americans in the Medicaid enrollment files, so analyses of associations between prenatal WIC participation and outcomes measured in Vital Records data (in the prenatal analysis) are more broadly generalizable to WIC participants served by the State agency or one of the seven participating ITOs (including Native Americans).

Aside from these major limitations in the availability of data for subgroups in each of the participating States, the process of calculating measures of Medicaid fee-for-service costs and measures of health care utilization from the Medicaid claims was straightforward. However, the assessment of Medicaid costs and use of Medicaid-paid health care services might not provide a comprehensive picture of health care costs or utilization. Health care services that were not reimbursed by Medicaid, such as services provided at county health clinics, are not included in the WM-II measures (which are based on Medicaid data alone). This exception might be a particular concern for measures related to child immunizations and prenatal care.

[18] County of residence, rather than individual characteristics of Medicaid beneficiaries, determines managed care enrollment in Missouri (Missouri HealthNet Division 2013). For analyses of Medicaid costs in the prenatal analysis, all mother-infant dyads who had one or more claims paid by a managed care plan were dropped from the sample. Similarly, the children's analysis excluded children if a managed care plan paid one or more claims or if the children did not have any claims in 2010 but lived in a managed care county. Compared with an alternative exclusion criterion based on county of residence, this approach accounted for errors in the address fields and for households that moved.

[19] The study team used available data on health care use to impute what Medicaid costs would have been for managed care beneficiaries in Missouri if they had been enrolled in fee-for-service Medicaid. Chapter III, Section D summarizes findings from this analysis.

[20] WM-I excluded managed care beneficiaries from all analyses—about 5 percent of Medicaid beneficiaries in Florida and 9 percent in Minnesota (Devaney et al. 1990, p. 21). Using the same rule in WM-II would have excluded more than half of Missouri's analysis sample. Therefore, WM-II included managed care beneficiaries whenever possible—that is, in all analyses except analyses of Medicaid costs.

### 3. Vital Records birth, fetal death, and death certificates

The study team encountered relatively few issues in the collection of birth, fetal death, and death certificates data from the Vital Records agencies in Missouri and Oklahoma. As noted previously, birth and fetal death certificates were not available for infants and children who were enrolled in the States' Medicaid programs but were born in another State. For this reason, findings about the associations between WIC participation and outcomes measured in Vital Records data (for example, birthweight) are generalizable to in-State births only. Similarly, infant mortality might be underreported if infants died outside the State in which they were born.

As mentioned in Chapter I, the U.S. Standard Birth Certificate was enhanced in 2003 to include a number of new or redefined variables. The data collected with this new version of the birth certificate offered new or improved outcomes or covariates for the WM-II prenatal analyses (relative to the data available use in WM-I). For example, the new version of the birth certificate includes measures of the number of cigarettes smoked per day for the three months before pregnancy (a useful covariate) and for each trimester of pregnancy (a primary outcome in the prenatal analysis). Oklahoma and Missouri both implemented the revised birth certificate in 2010, so these data were available for the prenatal analyses. However, the birth certificate data used for the children's analysis were collected using the 1989 U.S. Standard Birth Certificate. Therefore, the children's analysis could include only variables that were available on the older version of the birth certificate, and the resulting list of characteristics was more limited than the characteristics used in the prenatal analysis.

A number of studies have demonstrated that the reliability and validity of Vital Records data is generally high. Furthermore, several studies that examined the quality of data on birthweight and gestational age—which provided the basis for three key birth outcome measures in the prenatal analysis and were used as covariates in the children's analysis—generally concluded that the reliability and validity of these data elements are high. However, gestational age is more prone to (typically modest) problems of over- or underreporting than birthweight (Clayton et al. 2013; DiGiuseppe et al. 2002; Lain et al. 2012; Reichman and Schwartz-Soicher 2007). In a study that compared a sample of 1,095 birth certificates from two States (four hospitals) in 2003 with data abstracted from medical records, Martin et al. (2013) found that 90 to 91 percent of records matched exactly for birthweight (in grams) and that virtually all records (99.7 and 99.4 percent in the two States) were within 500 grams. The rates of agreement for the percentage of infants classified as low birthweight and very low birthweight exceeded 95 percent.

In WM-II, measures of gestational age were based on the obstetric estimate.[21] In validation studies, findings for gestational age at delivery based on obstetric estimate were generally favorable (compared to those based on the date the woman's last normal menses began), although they varied across two States (Martin et al. 2013). In one State, 92 percent of records matched exactly on gestational age (in weeks), but only 67 percent of records matched exactly in the other State. After recoding the data to assess agreement of gestational age within two weeks, the rates of agreement increased to 100 and 98 percent in the two States, respectively.

[21] See Martin et al. (2015) for details on the difference between measures of gestational age based on the obstetric estimate and measures based on the date of the mother's last normal menses.

Findings about the reliability and validity of other Vital Records-based data elements included in the prenatal and children's analyses include the following:

- Martin et al. (2013) found that breastfeeding at discharge had high sensitivity. That is, when a medical record reported that an infant was being breastfed at discharge, the birth certificate tended to report breastfeeding at discharge. However, breastfeeding rates tend to drop over time, so rates of breastfeeding at discharge are only a proxy for the proportion of infants who were breastfed later in infancy (Centers for Disease Control and Prevention [CDC] 2016).
- Several studies have found that prenatal care and smoking are not always recorded accurately on the birth certificate (see, for example, DiGiuseppe et al. 2002; Land et al. 2012; Martin et al. 2013; Reichman and Schwartz-Soicher 2007; Roohan et al. 2003). Smoking is often underreported, and this underreporting could be more prevalent among certain subgroups of mothers.
- Several studies have found that gestational diabetes and gestational hypertension are underreported on the birth certificate (see, for example, DiGiuseppe et al. 2002; Martin et al. 2013; Reichman and Schwartz-Soicher 2007; and Roohan et al. 2003).
- There is less clarity about the birth certificate fields used to construct measures of maternal weight gain during pregnancy. Rasmussen and Yaktine (2009) noted more concerns with mothers' pre-pregnancy weight and height (which are usually self-reported by the mother at the delivery) than with weight at delivery (which is usually abstracted from medical records). Park et al. (2011) compared data from birth certificates with data collected by Florida's WIC program and found pre-pregnancy weight, height, and BMI from birth certificates were generally reliable.
- A number of data elements in the Vital Records data had missing data, although the rates were not substantially different than the rates in WM-I and the Buescher study. (Chapters III and IV discuss approaches used by the study team to address missing data.)

In conclusion, Vital Records data likely represented high-quality data for birthweight, gestational age, and breastfeeding at discharge. However, the quality of the data for other outcomes (smoking during pregnancy, adequacy of prenatal care, weight gain during pregnancy), and health complications during pregnancy (gestational diabetes and gestational hypertension) is less certain.

## E. Conclusions and implications

The successful creation of the linked analytic databases for Missouri and Oklahoma demonstrate that it is feasible to collect data from State WIC, Medicaid, and Vital Records agencies and to link these data for individual women, infants, and children. Moreover, the availability of data collected in the 2003 U.S. Standard Birth Certificate allowed the study team to include a number of variables that were unavailable at the time WM-I data were collected. Thus, WM-II demonstrated that it was feasible to assess the relationship between prenatal WIC participation and an expanded set of pregnancy and birth outcomes (birth outcomes, maternal behavior, and maternal health), and to enhance the approach used in WM-I by better controlling for differences between WIC participants and nonparticipants in the prenatal analysis.

WM-II encountered challenges in measuring Medicaid costs and assessing the association between WIC participation and Medicaid costs. Cost data were not available for all records in the linked data set, which limited the assessment of cost-related outcomes to a subset of the sample in both Missouri and Oklahoma. Cost data were available for Medicaid beneficiaries covered by fee-for-service arrangements, but not for beneficiaries covered by managed care arrangements. In Missouri, about two-thirds of the samples included in the prenatal and children's analyses were covered by managed care and about one-third were covered by fee-for-service. Consequently, Medicaid cost data were available for only about one-third of the prenatal and children's analysis samples in Missouri. In Oklahoma, all Medicaid beneficiaries were covered by fee-for-service, but Oklahoma did not provide Medicaid claims data for Native Americans. In Oklahoma, data on Medicaid costs were available for 83 percent of the prenatal analysis sample and 81 percent of the children's analysis sample.

It was not feasible to assess the association between WIC participation and Medicaid costs among the two-thirds of sample members in Missouri who were covered by managed care. It is likely that studies focused on Medicaid costs will continue to be difficult to conduct, given the increase in Medicaid managed care over the past few decades—in 2016, about 68 percent of all Medicaid beneficiaries were enrolled in a comprehensive managed care plan (Mathematica Policy Research 2018). However, State Medicaid agencies and CMS are working to improve the quality of managed care encounter claims data, and some States now collect data on the costs paid by managed care plans to health care providers for managed care encounter claims. Thus, although WM-II was not able to assess the relationship between WIC participation and Medicaid costs among beneficiaries enrolled in managed care, future research might be able to examine the relationship between WIC participation and managed care plans' costs in select States. This option would be limited to States with more comprehensive managed care encounter records, or States where costs could be imputed.

Although Medicaid managed care claims do not provide data on Medicaid costs, they can be used, as they were in WM-II, to assess a broad range of health care utilization measures. Indeed, analyses that focus on *other* Medicaid outcomes—outcomes that can be measured for fee-for-service and managed care beneficiaries—are possible and could be an important area for future research. In particular, future studies of prenatal WIC participation would benefit from being expanded to include a wider array of measures related to maternal health, maternal behavior, and health care access and utilization. Examples include claims-based measures from the Center for Medicaid and CHIP Services' (CMCS's) Core Set of Children's and Adult's Health Care Quality Measures (CMCS 2012, 2013). In addition, it is important to recognize that the presence of Medicaid managed care has no impact on the feasibility of assessing associations between WIC participation and birth outcomes or the other Vital Records-based outcomes examined in the WM-II prenatal analysis.[22]

[22] Supplemental analyses, discussed in Chapters III and IV, measured associations between WIC participation and birth certificate outcomes (in the prenatal analysis) and health care utilization (in the prenatal and children's

The experience of collecting data for Oklahoma demonstrates that expansion of WM-II to include States with ITOs might present special challenges.[23] To obtain findings that are fully representative of all WIC participants in a given State, all ITOs operating in the State must contribute data to the study. Depending on the number of ITOs in the State and their internal connections, the task of obtaining complete data might be even more challenging than it was in WM-II. The seven ITOs in Oklahoma that provided data for WM-II used the same management information system—the Successful Partners in Reaching Innovative Technology (SPIRIT) system. This commonality greatly simplified the negotiation and data acquisition process relative to what would have been required to work with seven separate entities.

Similarly, the experience with Oklahoma demonstrates that expansion of WM-II to include States with large populations of Native Americans could present special challenges. Specifically, Medicaid claims submitted by the Indian Health Service to States' Medicaid agencies might be less complete than claims submitted by other providers.

Despite the limitations that affected the representativeness of the analysis samples and the availability of data on Medicaid costs, FNS elected to move ahead with implementing the prenatal and children's analyses. These analyses are described in detail in Chapters III and IV, respectively. Because of the limitations described in this chapter, findings from these analyses should be interpreted with caution. Although the results of the WM-II analyses have high internal validity, the data limitations mean that results are not necessarily generalizable to the entire Medicaid populations in Missouri or Oklahoma, or to Medicaid populations in other States. The study team conducted a number of sensitivity analyses and robustness checks to shed light on the implications of the sample limitations. Key findings from these analyses are summarized in Chapters III and IV.

As described in Chapter I, WM-II intentionally focused on two carefully selected States. As designed, the study was not feasible in many States and the District of Columbia for one or more of the following reasons: (1) data from the revised birth certificate were unavailable for 2011 or earlier; (2) the comparison group would be very small because there were few Medicaid-eligible beneficiaries who did not participate in WIC; (3) the State had too few Medicaid-covered births for statistical precision; or (4) the State had a high rate of Medicaid managed care penetration, with few non-Medicaid managed care births per year (Kranker et al. 2013). Adjusting the existing study design along one or two of these dimensions and omitting the focus on Medicaid costs might render a study on outcomes measured in Vital Records and Medicaid data and associated with WIC participation feasible in more States. For example, if the study collected data for more than one year, it could include States with smaller Medicaid populations. Another option for obtaining the requisite sample sizes is to pool data from two or more States, although this approach would require moving away from State-specific estimates.

analyses) separately for managed care and fee-for-service beneficiaries in Missouri and separately for Native Americans and non-Native Americans in Oklahoma.

[23] ITOs operate separate WIC programs in Arizona, Colorado, Georgia, Maine, Mississippi, Nebraska, New Mexico, New York, North Carolina, North Dakota, South Dakota, and Wyoming.

# III. FINDINGS FROM THE PRENATAL ANALYSIS

By providing nutritious foods, nutrition education, and screening and referral to health and social services, WIC aims to promote healthy pregnancies and positive birth outcomes among low-income women who are at nutritional risk. WIC also promotes and supports the initiation of breastfeeding and supports continuation of it among postpartum mothers who choose to breastfeed (Oliveira and Frazao 2015). If prenatal WIC participation lowers the incidence of adverse birth outcomes such as preterm birth and low birthweight, it could also decrease Medicaid costs. However, these cost savings might be offset if WIC improves mothers' links to the health care system, leading to increases in other types of health care utilization, especially in the short term.

This chapter presents findings from the prenatal analysis, which was modeled on the WM-I study and implemented using the linked database and analytic sample described in Chapter II. Findings from these analyses should be interpreted with caution because of the data limitations described in Chapter II. Although the results of the analyses are expected to have high internal validity, the data limitations mean that results are not necessarily generalizable to the entire Medicaid populations in Missouri or Oklahoma, or to Medicaid populations in other States. The study team conducted a number of sensitivity analyses and robustness checks to shed light on the implications of the sample limitations. Findings from these supplementary analyses are summarized in this chapter and in appendices referenced throughout the chapter. Appendices are included in a separate volume.

## A. Analytic approach

The prenatal analysis estimated the association between WIC participation during pregnancy and birth outcomes, maternal behaviors, maternal health outcomes, and health care costs among Medicaid-covered births (see Chapter II). The analysis compared outcomes for women who participated in WIC during their pregnancy and had a Medicaid-covered birth (and their infants) with outcomes for a comparison group of women who had a Medicaid-covered birth but did not participate in WIC during pregnancy (and their infants).

### 1. Defining WIC participation

The study team used administrative records from the WIC program to identify mothers who participated in WIC sometime during their pregnancies. Specifically, the team based its definition of WIC participation on whether WIC participants actually redeemed one or more of their WIC food instruments rather than on WIC certification status alone. The primary measure of WIC participation in this analysis classified a woman as a WIC participant if she redeemed at least one food instrument during the course of her pregnancy. Using the above definition of WIC participation, 71 percent of the women in the Missouri analysis sample were WIC participants and 73 percent of the women in the Oklahoma analysis sample were WIC participants (see Chapter II, Table II.4).

The measure of WIC participation used in this analysis differs from the regulatory definition, which includes all women who are issued a food instrument, regardless of redemption. The advantage to using instrument redemption to identify WIC participants is that it excludes women who enrolled in WIC but never actually redeemed the food instruments issued to them. Descriptive statistics show that 7 to 8 percent of women certified as prenatal WIC participants did not redeem a food instrument (Appendix E, Table E.1). For purposes of the prenatal analysis, these women were coded as nonparticipants. This approach to defining WIC participation is also superior to using a self-reported measure of WIC participation available on the birth certificate. The birth certificate measure suffers from low specificity. In Missouri and Oklahoma, respectively, 31 and 28 percent of actual nonparticipants (based on administrative data) self-reported as participants while 3 and 5 percent of actual participants self-reported as nonparticipants.[24]

The study team also created other measures of WIC participation, summarized in Table III.1, which classified WIC participants based on the timing of their participation and the dose or intensity of their participation. The study team created three binary measures to identify women who first redeemed a WIC food instrument during the first, second, or third trimester of pregnancy. Patterns of participation were similar in Missouri and Oklahoma—44 or 45 percent of prenatal WIC participants first participated in WIC during the first trimester of their pregnancy, 37 or 38 percent began WIC participation during their second trimester, and the remaining 18 percent did not begin participating in WIC until their third trimester (Table III.2).

In addition, the team created a categorical measure of low, medium, and high levels of WIC participation, based on the number of months during pregnancy a woman received WIC benefits. The measures of high, medium, and low participation are highly correlated with first beginning WIC participation in the first, second, or third trimesters of pregnancy. Minor differences arise because (1) women have different pregnancy lengths and (2) some women drop out of WIC after beginning participation.

[24] Appendix F shows how the results reported in this chapter change when alternative measures of WIC participation are used. As expected, the results with these alternative WIC participation measures generally were attenuated (closer to zero).

## Table III.1. Measures of prenatal WIC participation

| Measure | Definition |
|---|---|
| Any WIC participation (binary measure) | = 1 if at least one food instrument was redeemed during pregnancy; 0 otherwise |
| Timing of WIC participation[a] (binary measures of first-, second-, and third-trimester participation) | First-, second-, and third-trimester participation<br>= 1 if first food instrument was redeemed during the first, second, and third trimesters of pregnancy, respectively; 0 otherwise |
| Length of WIC participation[b,c] (binary measures) | Low, medium, and high levels of participation based on number of months during pregnancy that at least one food instrument was redeemed<br>= 1 if food instruments were redeemed for 1–33 percent of pregnancy, 34–67 percent of pregnancy, and > 67 percent of pregnancy, respectively; 0 otherwise |

[a] The first, second, and third trimesters are defined as weeks 1 through 13, weeks 14 through 26, and 27 weeks or later, respectively.

[b] Because pregnancies will vary in length, months of WIC participation are expressed as a percentage of pregnancy.

[c] The beginning of the pregnancy was estimated by subtracting gestational age (from the birth certificate) from the date of birth.

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

## Table III.2. Trimester WIC participation began among WIC participants

| Trimester WIC participation began | Missouri | | Oklahoma | |
|---|---|---|---|---|
| | Number | Percentage | Number | Percentage |
| First | 11,884 | 45 | 9,825 | 44 |
| Second | 9,939 | 37 | 8,656 | 38 |
| Third | 4,880 | 18 | 4,056 | 18 |
| **Total** | **26,703** | **100** | **22,537** | **100** |

Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Note: Based on Medicaid-covered births in Missouri from April 2010 to March 2011 and in Oklahoma from February 2010 to January 2011 linked with a Vital Records birth certificate.

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

### 2. Outcome measures

The WM-II prenatal analysis was modeled on the WM-I study, which estimated the association between WIC participation and birth outcomes (birthweight and gestational age) and Medicaid costs from birth through 60 days postpartum (Devaney et al. 1992). As shown in Table III.3, the WM-II prenatal analysis was expanded to include a number of additional outcomes. Specifically, the prenatal analysis assessed the association between prenatal WIC participation and outcomes in four different domains: (1) birth outcomes, (2) maternal behaviors, (3) maternal health, and (4) Medicaid costs.

The following sections describe the outcome measures and Table III.3 summarizes them. The table identifies primary and secondary outcomes in each domain. As discussed in Section A.3, below, the main analysis focused on the primary outcomes and the use of rigorous statistical methods. The number of primary outcomes was limited to just one or a few outcomes in each `domain. This is because as the number of statistical tests (to assess differences between WIC participants and nonparticipants) increases, so does the chance of spurious results or false positives (Schochet 2009). The analysis of secondary outcomes did not use the same level of statistical control, and the findings are thus more exploratory. For example, findings for secondary outcomes might suggest hypotheses—new primary outcomes—for future research. Findings for all primary outcomes are discussed in this chapter; secondary outcomes are also discussed in this chapter, with detailed results presented in Appendix E.

### Table III.3. Outcome measures for the prenatal analysis

| Construct | Measure | Definition | Primary outcome | Secondary outcome | Included in WM-I | Source |
|---|---|---|---|---|---|---|
| **Domain: Birth outcomes** | | | | | | |
| Birthweight | Low birthweight | Binary indicator of birthweight fewer than 2,500 g | ✓ | | ✓ | BC |
| | Very low birthweight | Binary indicator of birthweight fewer than 1,500 g | ✓ | | | BC |
| | Birthweight | Continuous measure in g | | ✓ | ✓ | BC |
| | High birthweight | Binary indicator of birthweight more than 4,000 g | | ✓ | | BC |
| Fetal growth | SGA | Binary indicator of birthweight below the 10th percentile for gestational age (gender and race/ethnicity specific)[a] | ✓ | | | BC |
| | Large-for-gestational-age | Binary indicator of birthweight above the 90th percentile for gestational age (gender and race/ethnicity specific)[a] | | ✓ | | BC |
| | Full-term low birthweight | Binary indicator for the joint occurrence of gestation ≥37 weeks and birthweight fewer than 2,500 g | | ✓ | | BC |
| Infant mortality | Neonatal mortality | Binary indicator of infant death fewer than 28 days after birth | ✓ | | | DC |
| | Overall infant mortality | Binary indicator of infant death before 1 year of age | | ✓ | | DC |
| | Postneonatal mortality | Binary indicator of infant death 28 or more days after birth and before 1 year of age | | ✓ | | DC |
| Gestational age | Preterm birth | Binary indicator of gestation fewer than 37 weeks | | ✓[b] | ✓ | BC |
| | Gestational age | Continuous measure in weeks | | ✓[b] | ✓ | BC |
| | Very preterm birth | Binary indicator of gestation 32 or fewer weeks | | ✓[b] | | BC |

Table III.3. (*continued*)

| Construct | Measure | Definition | Primary outcome | Secondary outcome | Included in WM-I | Source |
|---|---|---|---|---|---|---|
| **Domain: Maternal behaviors** | | | | | | |
| Breastfeeding | Breastfeeding at discharge | Binary indicator of whether the newborn was breastfed at discharge | ✓ | | | BC |
| Smoking | Smoking anytime during pregnancy | Binary indicator of whether a mother reported having smoked anytime during pregnancy | | ✓ | | BC |
| | Smoking during third trimester of pregnancy | Binary indicator for smoking during the third trimester of pregnancy | | ✓[c] | | BC |
| | Level of smoking during third trimester of pregnancy | Binary indicators of high (≥ 21), medium (11–20), low (1–10), and no smoking during third trimester of pregnancy, based on the number of cigarettes smoked per day | | ✓[c] | | BC |
| Adequacy of prenatal care | Adequate prenatal care (Kessner index) | Binary indicator of adequate prenatal care based on the Kessner index of prenatal care adequacy (Kessner et al. 1973) | | ✓ | - | BC |
| | Adequate prenatal care | Binary indicator of adequate or adequate plus prenatal care based on the APNCU index (Kotelchuck 1994) | | ✓ | | BC |
| | Adequate prenatal care—modified APNCU-2M index | Binary indicator of adequate or adequate plus prenatal care from modified APNCU index (VanderWeele et al. 2009) | | ✓ | | BC |
| | Any Medicaid-paid prenatal care | Binary indicator of 1 or more prenatal care visits in the Medicaid claims data (based on Center for Medicaid and CHIP Services [CMCS] 2012, measure 1) | | ✓ | | MF |

Table III.3. (*continued*)

| Construct | Measure | Definition | Primary outcome | Secondary outcome | Included in WM-I | Source |
|---|---|---|---|---|---|---|
| **Domain: Maternal health** | | | | | | |
| Weight gain during pregnancy | Lower than recommended | Binary indicator of pregnancy weight gain that was 10 percent or more below the IOM recommendations (Rasmussen and Yaktine 2009) | ✓ | | | BC |
| | Higher than recommended | Binary indicator of pregnancy weight gain that was 10 percent or more above the IOM recommendations (Rasmussen and Yaktine 2009) | ✓ | | | BC |
| Health complications during pregnancy | Gestational diabetes | Binary indicator of whether the mother developed gestational diabetes during the pregnancy | | ✓ | | BC |
| | Gestational hypertension | Binary indicator of whether the mother developed gestational hypertension during the pregnancy | | ✓ | | BC |
| Method of delivery | Cesarean section | Binary indicator of whether the mother delivered the infant via cesarean section[d] | | ✓ | | MF |
| **Domain: Medicaid costs** | | | | | | |
| Medicaid costs for the mother and infant | Medicaid costs *from birth through 60 days postpartum* ($) | Continuous measure of costs for mothers' labor and delivery and other medical care through 60 days postpartum and costs for infants at birth and through 60 days postpartum (from fee-for-service Medicaid claims)[e,f] | ✓ | | ✓ | MF |
| | Medicaid costs *from the prenatal period through 60 days postpartum* ($) | Continuous measure of costs for mothers' prenatal care, labor and delivery, and other medical care through 60 days postpartum and costs for newborns at birth and through 60 days postpartum (from fee-for-service Medicaid claims)[e,f] | ✓ | | | MF |

Table III.3. (*continued*)

Notes: For outcome measures obtained from the BC, the sample was limited, on a variable-by-variable basis, to observations with nonmissing data.

For all Medicaid cost outcomes, the sample in Missouri was limited to fee-for-service Medicaid beneficiaries.

Appendix E, Table E.2 lists measures of health care utilization and Medicaid costs included for exploratory analyses. Appendix E, Table E.3 provides additional details on the construction of outcome measures from the Medicaid files.

[a] The 10th and 90th percentiles were estimated with data on all U.S. births using the 2008 and 2009 Natality Files from the Centers for Disease Control and Prevention, National Center for Health Statistics, Division of Vital Statistics (available at http://www.cdc.gov/nchs/data_access/Vitalstatsonline.htm). Percentiles were calculated by gestational age (by week), gender, race/ethnicity, and plurality (singleton or multiple), similar to Alexander et al. (1999).

[b] A supplementary analysis included gestational age as an outcome. In addition, a supplementary analysis of first-trimester WIC participants included the prevalence of preterm births as an outcome measure. For these analyses, the samples were not matched on gestational age.

[c] A supplementary analysis of first-trimester WIC participants included smoking in the third trimester as an outcome measure.

[d] Measure equals one if one or more claims associated with the birth or delivery had a diagnosis or procedural code indicating a cesarean section occurred.

[e] For 2 percent and 13 percent of Medicaid-covered births in Missouri and Oklahoma, respectively, Medicaid only covered the mother's delivery or the infant's birth, but not both. In these cases, some Medicaid cost outcomes are set to $0, as was done in WM-I. The approach is rooted in the idea that the cost of the "missing" mother or infant *truly* was $0. In alternative specifications, discussed in Appendix F, the unlinked Medicaid-covered births were dropped and results were similar.

[f] In the primary specification, for Medicaid claims that started within the 60-day period after birth but extended beyond the 60-day period, the Medicaid reimbursements were prorated according to the proportion of the service period that occurred within the 60-day postpartum period. In alternative specifications, discussed in Appendix F, the costs were not prorated. In some cases, it is difficult to categorize a particular claim as occurring during the prenatal or delivery period or during the postpartum period. However, these measures, in combination, will measure all health care utilization in the two periods. That is, there could be measurement error for the two measures separately, but the sum of the two measures will be accurate. All infant claims were assigned to the postpartum period.

APNCU = Adequacy of Prenatal Care Utilization; BC = birth certificate; CHIP = Children's Health Insurance Program; CMCS = Center for Medicaid and CHIP Services; DC = death certificate; g = grams; IOM = Institute of Medicine; MF = Medicaid files; SGA = small-for-gestational-age.

### a. Birth outcomes

Primary outcomes in this domain include the prevalence of (1) low birthweight, (2) very low birthweight, (3) SGA births, and (4) the neonatal mortality rate. The focus on the prevalence of low birthweight (fewer than 2,500 grams) and very low birthweight (fewer than 1,500 grams) follows prior studies and reflects the fact that these infants often need expensive medical interventions at birth. A measure of fetal growth is also included to distinguish between two broad categories of low birthweight infants—those born prematurely and those who are SGA. SGA is an indication of compromised fetal growth (intrauterine growth retardation). Joyce et al. (2008) argued that a strong case could be made for expecting an association between SGA and prenatal interventions, including participation in the WIC program, because intrauterine growth retardation is closely linked to modifiable factors that these interventions target, including diet, smoking, and maternal weight gain. Finally, based on findings from WM-I, the neonatal mortality rate (death within 28 days of birth) was included as a primary outcome. Because infant deaths occur infrequently, mortality rates are presented as the number of deaths per 1,000 births.

In addition to these four primary outcomes, WM-I also included gestational age and related measures (such as the preterm birth rate) as birth outcome measures. In WM-II, the analytic approach specifically controlled for gestational age (as described in Section III.A.3.b), so these outcomes were precluded from being primary birth outcomes. Supplemental analyses, described later in this chapter, examined the associations between WIC participation and gestational age and the prevalence of preterm births.

Secondary outcomes in this domain include a continuous measure of birthweight, the prevalence of high birthweight and large-for-gestational-age infants (these infants could experience birth injury and hypertension and are more likely to require delivery by cesarean section), full-term low birthweight (an alternative measure of fetal growth), and rates of infant mortality measured over longer time frames (up to 12 months).

### b. Maternal behaviors

In this domain, the analysis focused on breastfeeding at discharge as a primary outcome because promoting and supporting breastfeeding is central to WIC's mission (FNS 2009). This measure is reported on the birth certificate. Although it would be interesting to include additional measures on breastfeeding duration, breastfeeding at discharge is the only outcome measure for breastfeeding available in Vital Records or Medicaid data.[25] According to 2008 data from 29 States collected by the CDC Pregnancy Risk Assessment Monitoring System (PRAMS), 77 percent of Medicaid recipients who initiated breastfeeding continued to breastfeed at four weeks postpartum (CDC 2014, Table 3).

Secondary outcomes related to maternal health behaviors explore the adequacy of prenatal care and women's smoking behaviors during pregnancy. The study included three different indices of prenatal care because the association between prenatal WIC participation and the adequacy of prenatal care may be sensitive to the index used. All three indices use information on the timing of entry into prenatal care, the number of prenatal care visits, and the infant's gestational age at birth, but they use different algorithms. The Adequacy of Prenatal Care Utilization (APNCU) index was designed to address several limitations of the Kessner index (which the WM-I study had used), including a disproportionate emphasis on the timing of entry into prenatal care, lack of distinction between the timing of prenatal care initiation and poor subsequent utilization of prenatal care services, and inaccurate assessment of prenatal care utilization for full- and post-term pregnancies (Kotelchuck 1994). Although the APNCU index is generally considered the standard for assessing adequacy of prenatal care, some concerns about potential bias have been raised (VanderWeele et al. 2009); the modified APNCU-2M index addresses these concerns. WM-II also includes measures of smoking behaviors, specifically an indicator of a woman's smoking anytime during her pregnancy, an indicator of a woman's smoking in the third trimester, and measures of the level of smoking (based on the number of cigarettes per day) in the third trimester. Analyses based on these outcomes should be interpreted with caution given there are some concerns about data quality for this measure (see Chapter II).

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[25] One point of comparison is data on breastfeeding initiation collected by the Oklahoma WIC agency *for WIC participants only*, which indicate that breastfeeding initiation rates were 75 to 80 percent during the study period—*higher* than the rates for breastfeeding at discharge estimate in WM-II for Oklahoma WIC participants. On the other hand, data on breastfeeding initiation collected by the Missouri WIC agency (again, for WIC participants only) indicate that slightly fewer than half of the women during the study period initiated breastfeeding, which is *lower* than WM-II estimates. Differences between State-level estimates of breastfeeding initiation and Vital Records estimates may be due to differences in data sources, measures, and/or the timing of data collection.

### c. Maternal health

Maternal weight gain was chosen as the primary outcome related to maternal health because inappropriate weight gain during pregnancy is the leading nutritional risk among pregnant women in WIC (Johnson et al. 2013). Consequently, promoting appropriate weight gain is a common focus of WIC nutrition education (Fox et al. 1998). The WM-II study team used information provided on the birth certificate (mother's height as well as her weight before pregnancy and at delivery) to calculate weight gain during pregnancy, and then compared the estimated weight gain against recommendations made by the Institute of Medicine (IOM) (Rasmussen and Yaktine 2009), which took into account the mother's pre-pregnancy BMI. Researchers also used birth certificate information to identify mothers whose pregnancy weight gain was more than 10 percent above or below the IOM recommendations.

Secondary maternal health outcomes include the diagnosis of gestational diabetes and gestational hypertension and an indication of whether the mother delivered the infant via cesarean section. However, results for gestational diabetes and gestational hypertension should be interpreted with caution given that prior studies indicate these two measures are underreported on the birth certificate (see Chapter II).

### d. Medicaid costs

The prenatal analysis included two primary outcomes related to Medicaid costs. The first measure is comparable to the measure used in WM-I and includes Medicaid costs *from birth through 60 days postpartum*.[26] The second measure includes Medicaid costs *from the prenatal period through 60 days postpartum*. Thus, the second measure assesses total Medicaid costs associated with a pregnancy and birth—including Medicaid costs for mothers' prenatal care, labor and delivery, and other medical care through 60 days postpartum and costs for newborns at birth and through 60 days postpartum. The first measure does not include Medicaid costs during the prenatal period. As described in Chapter II, Medicaid costs in Missouri were calculated only for Medicaid beneficiaries in Missouri's fee-for-service program. In Oklahoma, Medicaid costs were calculated only for non-Native Americans.

As described later in this chapter, the study team also conducted exploratory analyses to examine the composition of Medicaid costs for WIC participants and nonparticipants, that is, Medicaid costs disaggregated into costs for inpatient (hospital) services and all other services, and associations between prenatal WIC participation and measures of health care utilization.

## 3. Analysis methods

As noted in Chapter I, one goal of WM-II was to update and expand WM-I using enhanced analysis methods. Thus, the prenatal analysis builds on rather than formally replicates WM-I methods. Naturally, however, readers might be interested in comparing results across the two studies. To facilitate such comparisons, the study team implemented supplementary analyses that replicated the WM-I approach as closely as possible using more recent administrative data.

[26] The measure of Medicaid costs used in WM-I was defined in the legislation that mandated the study.

Section D describes these supplementary analyses and their results. The rest of this chapter describes the methods used in the main WM-II analysis.

To assess the associations between prenatal WIC participation and the outcomes listed in Table III.3, two potential sources of bias must be addressed: selection bias and gestational-age bias. In addition, given the multiple outcomes examined in this study, concerns about the potential for spurious findings must also be considered. The sections that follow describe the nature of the concerns in these three areas as well as the methods used to address them. The section concludes by describing how the methods were adapted for conducting subgroup analyses.

**a. Addressing selection bias**

Selection bias is a concern because of the non-experimental nature of the study. All pregnant women enrolled in Medicaid are eligible to participate in WIC, but not all of them do. This raises a concern that characteristics of mothers who choose to participate in WIC might differ from those of nonparticipants in ways that can affect the outcomes of interest. Results presented later in this chapter (Tables III.5 and III.6) show that nonparticipants do, in fact, differ from WIC participants in a number of ways (although most differences are relatively small). The two groups may also differ in ways that the available data cannot observe. For example, pregnant women who participate in WIC might be more health conscious than women who do not participate or they could be more knowledgeable about and connected to prenatal care. Alternatively, efforts to enroll pregnant women in WIC might target women at higher risk for adverse birth outcomes. Consequently, observed differences in outcomes for WIC participants and nonparticipants could result from these underlying differences rather than the influence of WIC. Selection bias is a consistent concern in the WIC literature (Colman et al. 2012).

To address selection bias, the study team used a sophisticated observational design to match WIC participants and nonparticipants as closely as possible, thereby reducing the likelihood that underlying differences are responsible for estimated effects of WIC. Researchers frequently use multivariate regression techniques to control for selection bias, and most previous studies of prenatal WIC participation have used these techniques. In recent years, however, researchers interested in understanding the impact of social and educational programs have moved away from regression methods. This shift is due, at least in part, to concerns that regression-based estimates can be biased when functional form assumptions are inaccurate, particularly when the sample is not balanced (Imbens and Wooldridge 2009; Imbens 2015). Many researchers have employed alternative approaches, generally referred to as matching methods, to create a comparison group that is as similar as possible to the treatment group on observable characteristics (see, for example, Rosenbaum and Rubin 1983; Dehejia and Wahba 2002; Imbens and Rubin 2015; Stuart 2010). Matching methods can reduce bias in observational studies when relevant data on characteristics are available to researchers for use as matching variables although, absent a randomized trial, the potential for unobserved confounding remains. Limiting the comparison group to a matched subsample that closely matches the treatment group on an array of observed characteristics will also reduce differences between the two groups on *unobserved characteristics* that are correlated with the matching variables (Stuart 2010). Several recent evaluations of WIC impacts have used research designs with matched comparison groups.[27]

The study team used inverse probability weighting (IPW) to create a comparison group of nonparticipants that closely matched the WIC participants on observable characteristics. A broad array of covariates or "matching variables" was used in creating a matched comparison group of nonparticipants. These variables, shown in Table III.4, included demographic characteristics of the mother and infant as well as several risk factors for birth complications, including whether the mother received prenatal care from a public clinic, her pregnancy history (number of previous live births and terminations), and a number of pregnancy risk factors. The list of matching variables also included household income and an indicator for aged, blind, or disabled Medicaid eligibility.

It is important to note that these analyses account for a number of maternal characteristics that were not available to the WM-I and other WIC-Medicaid studies. These variables, marked with an asterisk in Table III.4, were added to the 2003 revision to the U.S. Standard Birth Certificate or are available in the Medicaid files. For example, the birth certificate now includes information about whether the mother smoked in the three months before pregnancy and the number of cigarettes smoked per day. Prenatal WIC participation cannot affect smoking before a woman's first pregnancy (the women are not yet eligible for WIC), but smoking can act as a proxy for unobserved differences between participants and nonparticipants (for example, the mother's health consciousness). Other examples of important characteristics include whether the mother had a previous adverse birth outcome, previously had a short or very short inter-pregnancy interval (among women with a prior birth), or was foreign-born. Previous adverse outcomes and short inter-pregnancy intervals are both strong predictors of adverse birth outcomes (see Behrman and Butler [2007] for a review of the literature). Among low-income women, those who are foreign-born tend to have better birth outcomes than those who are native to the United States (Howard et al. 2006). In the case of missing data for the matching variables, the study team included an indicator variable for missing data as additional matching variables, except in a few cases in which an extremely small number of observations were missing data. In such cases, the missing data were addressed by combining the missing data category with the modal category.

Unless a study can identify a large WIC-eligible population that chooses not to participate in the program but still takes advantage of other available medical care, it is difficult to avoid conflating WIC impacts with the impacts of other health services. Recently, some researchers have addressed the issue of multicollinearity in prenatal care by limiting the study sample to WIC participants and nonparticipants who obtain similar levels of non-WIC services. For example, Joyce et al. (2005) limited the study sample to women with no previous live births who enrolled in prenatal care within four months of pregnancy. Based on this logic, the analyses in WM-II included enrollment in SNAP and TANF; and an indicator for whether the mother or infant was enrolled in Medicaid managed care (Missouri only)

[27] See Colman et al. (2012) for a review of the literature. Examples include Lazariu-Bauer et al. (2004), Rivera (2008), Gueorguieva et al. (2009), and Foster et al. (2010).

Some studies that have examined the association between prenatal WIC participation and birth outcomes, including WM-I, included adequacy of prenatal care as a control variable. However, WM-II did not include prenatal care as a matching variable. The rationale for this decision was that WIC could influence the adequacy of prenatal care (by referring women to needed health and social services) and, thereby, influence birth outcomes (Currie 1995). Inclusion of a potential outcome as a control variable can bias results toward the null (the models risk being over-controlled). For this reason, adequacy of prenatal care was included as a secondary outcome (Table III.3) and not included as a matching variable in the main analysis (Table III.4). Robustness checks discussed later in this chapter show that the main results are comparable when adequacy of prenatal care is included as a matching variable.

**Implementing IPW.** The first step in implementing IPW involved estimating a propensity score model in which WIC participation is a function of the observed characteristics or matching variables—all of the variables listed in Table III.4. The study team used estimated coefficients from the logit model to calculate a propensity score ($p$) for each sample member, which is the predicted probability of prenatal WIC participation. They then used the estimated propensity scores to construct a weight for each observation. Participants received a weight of 1, and nonparticipants received a weight equal to $p/(1 - p)$. (Weights were normalized to have a mean of 1.) This formula assigns greater weight to nonparticipants who are similar to WIC participants and lower weights to nonparticipants who are not similar to WIC participants.[28] Then, the mean of an outcome variable for the WIC participants is compared to the mean for the weighted nonparticipants (the matched comparison group).[29] The propensity score model and the difference in the two means are estimated in a system of equations by the generalized method of moments in order to calculate robust standard errors (SEs) that account for the fact that the propensity scores (and consequently, the weights) are estimated (Cattaneo 2010; Hansen 1982). This system of equations was reestimated separately for each outcome variable. A potential issue with IPW analyses is a need to restrict the propensity scores to a region of common empirical support (that is, the need to remove observations with extremely high or low propensity scores). As demonstrated in Appendix D, this was not a problem in this study.

[28] For more details on IPW, see Busso et al. (2014); Cattaneo (2010); Guo and Fraser (2010); Hirano et al. (2003); Huber et al. (2013); Imbens and Rubin (2015); and Stuart (2010). IPW methods were implemented in Stata (version 13.1) with the teffects ipw command and with custom programs (for reasons discussed below).

[29] When estimating causal impacts, the literature calls this estimate the *average treatment effect on the treated*. That is, it produces estimated associations between WIC participation and outcomes among the women who participated in WIC. This should be distinguished from the *average treatment effect*, which would alternatively estimate associations between WIC participation and outcomes in the hypothetical scenario in which all women participated in WIC.

## Table III.4. Matching variables used in the prenatal analysis

| Characteristic | Variables | Data source |
|---|---|---|
| **Mother's characteristics** | | |
| Age | 17 years or younger | BC |
| | 18 or 19 years | BC |
| | 20–34 years | BC |
| | 35 years and older | BC |
| Race/ethnicity | White non-Hispanic | BC |
| | Black non-Hispanic | BC |
| | Hispanic | BC |
| | American Indian or Alaska Native | BC |
| | Asian or Pacific Islander | BC |
| | Other | BC |
| | Multiple races | BC |
| Foreign-born status | Foreign-born | BC* |
| Marital status | Married | BC |
| Education | Less than high school | BC |
| | High school or GED | BC |
| | Some college credit but no degree | BC |
| | College degree[a] | BC |
| Rural residence | Rural residence | BC |
| Household income[b] | Income (as percentage of the FPL) | MF* |
| | Income $0 | MF* |
| Prenatal medical care from public clinic | Received prenatal care from a public clinic[c] | MF |
| SNAP participation[d] | Mother's enrollment in SNAP | MF* |
| | Infant's enrollment in SNAP | MF* |
| TANF participation | Household receives TANF benefits | MF* |
| Aged, blind, and/or disabled | Mother's enrollment in Medicaid on the basis of aged, blind, and/or disabled eligibility | MF* |
| Medicaid managed care beneficiary (Missouri only) | One or more claims from Medicaid managed care plan | MF* |
| **Newborn's characteristics** | | |
| Gender | Male | BC |
| **Pregnancy history** | | |
| Previous live births | Number of previous live births[d] | BC |
| Previous live terminations | Number of previous terminations[d] | BC |
| **Pregnancy risk factors** | | |
| Pre-pregnancy BMI | Less than 18.5 (underweight) | BC* |
| | 18.5–24.9 (normal) | BC* |
| | 25.0–29.9 (overweight) | BC* |
| | 30.0–39.9 (obese) | BC* |
| | 40 or higher (extremely obese) | BC* |
| Smoking before pregnancy | Smoked three months before pregnancy | BC* |
| | Number of cigarettes per day | BC* |
| Previous adverse birth outcomes | Cesarean delivery | BC* |
| | Preterm birth | BC* |
| | Other poor birth outcomes[f] | BC* |

Table III.4. (*continued*)

| Characteristic | Variables | Data source |
|---|---|---|
| Medical conditions | Pre-pregnancy diabetes | BC* |
| | Pre-pregnancy hypertension | BC* |
| Inter-pregnancy interval[g] | Fewer than 6 months (very short) | BC* |
| | 6–17 months (short) | BC* |
| Infertility treatment | Pregnancy resulted from infertility treatment | BC* |

Notes: As mentioned in the text, the primary specification of the propensity score model also included the gestational length of the pregnancy as a matching variable. Gestational age was included in the propensity score model as a continuous variable (in weeks) plus dummies for very preterm (32 weeks or less), preterm (33–36 weeks), or early (37 or 38 weeks) births.

The column on the right indicates the primary data source (BC or MF). In some cases, data from the primary data source were filled in with an alternative data source in the case of missing data. (For example, if the address from the BC was missing, rural residence was filled in using the address from the MF). For some variables, a dummy variable for missing data was included (not shown). In a few cases, so few observations were missing data that the missing data category was combined with the mode (see the footnotes to the corresponding tables). For outcomes from the MF, the propensity score model also included dummy variables to identify the small percentage of Medicaid-covered births in which only the mother or only the infant was a Medicaid beneficiary.

* Variable was not included in WM-I.

[a] This category includes women with at least a four-year college degree (bachelor's, master's, doctorate, and professional [M.D., D.D.S., D.V.M., J.D., or L.L.B.] degrees). Women with an associate's degree are included in the "some college but no degree" category.

[b] Household income was entered into the propensity score models with categorical variables for household income $0, 1 to 100 percent of the FPL, more than 100 percent of the FPL, or missing. The second and third categorical variables were also interacted with the continuous income measure (percentage of the FPL).

[c] Following the precedent WM-I, the analysis in WM-II used receipt of prenatal care from a public clinic as a matching variable. This variable equaled one if woman had had one or more Medicaid claims for prenatal care where the provider type or provider specialty was a Federally Qualified Health Center, county public health clinic, or other public entity. One reason to include this variable for matching is because public providers sometimes receive outside funding, and therefore the costs of care for these women may not be fully captured in Medicaid claims. Further, receiving care at a public clinic may be correlated with WIC participation and other unobserved characteristics. (In Oklahoma for WIC and Medicaid services to be collocated and integrated at county health clinics.)

[d] Data provided by a cognizant State agency in Missouri. Data on SNAP enrollment were unavailable in Oklahoma. Models in Missouri for the primary outcomes were reestimated with and without the SNAP participation variable and findings were comparable (Appendix F).

[e] Binary variables for 0, 1, 2, 3, 4, or 5 or more births or terminations.

[f] As coded in the U.S. Standard Birth Certificate (defined as perinatal death or SGA/intrauterine growth restricted birth).

[g] Inter-pregnancy interval was calculated from the infant's date of birth, the date of the most recent pregnancy (live birth or other outcome), and gestation length. Women were then categorized as follows: first birth, a very short inter-pregnancy interval (fewer than 6 months), short inter-pregnancy interval (6 to 17 months), other inter-pregnancy interval (more than 17 months), or unknown (missing data or mother's age at most recent pregnancy was fewer than 12 years or more than 55 years).

BC = birth certificate; BMI = body mass index; FPL = Federal poverty level; GED = general educational development (diploma); MF = Medicaid files; SGA = small-for-gestational-age; SNAP = Supplemental Nutrition Assistance Program; TANF = Temporary Assistance for Needy Families; WM-I = WIC-Medicaid Study I.

Data obtained from the birth certificate were missing for some mother-infant dyads, on a variable-by-variable basis. In general, this problem was not widespread, and rates of missing data were low and not noticeably different for WIC participants and nonparticipants (Appendix E, Table E.4).[30] In the main analyses, the sample for each outcome variable included the maximum number of Medicaid-covered births possible, after accounting for the restrictions related to managed care beneficiaries in Missouri and Native Americans in Oklahoma (discussed in Chapter II). Because the analysis sample varied across outcomes on a variable-by-variable basis, the propensity score model was reestimated and weights were computed separately for each outcome using the sample of WIC participants and nonparticipants for which the outcome variable was nonmissing.

In addition to its simplicity and computational advantages, IPW can be extended to estimate the relationship between the outcome of interest and different levels of WIC participation. As described previously, WM-II examined associations for WIC participants who began participations in the first, second, or third trimesters and for high, medium, and low lengths of WIC participation. The technique essentially involves comparing WIC enrollees with high participation, for example, to a matched comparison group of nonparticipants who are similar to the high-participation enrollees (Imbens 2000; Cattaneo 2010; Cattaneo et al. 2013). Results were comparable when the propensity scores for each level of participation were estimated with either a single multinomial logit model or with separate logit models. In addition, the matched comparison group of nonparticipants constructed with IPW were used to estimate the association between any WIC participation and Medicaid costs by quantile with methods from Bitler et al. (2006).

Overall, IPW performed well in creating a matched comparison group of nonparticipants for the prenatal analysis. Appendix D provides summary measures that demonstrate the success of the approach.

### b. Addressing gestational-age bias

Estimates of associations between prenatal WIC participation and outcomes of interest could be biased if the analysis does not account for the fact that women whose pregnancies last longer are less likely to experience an adverse birth outcome, such as delivering a low birthweight infant, and, at the same time, have a longer opportunity to enroll in WIC. That is, women who begin to participate in WIC late in pregnancy tend to have better birth outcomes than women who enroll early simply because their pregnancies lasted longer (Devaney et al. 1992; Joyce et al. 2008). Since many prenatal WIC participants enroll in WIC later in their pregnancies, unadjusted analyses show that women who participate in WIC have, on average, better birth outcomes than women who never enroll in WIC. Researchers have used the term *gestational-age bias* to refer to the bias that results from this phenomenon.

[30] Only three of the primary outcomes were subject to missing data on the birth certificate, and the percentage of cases with missing data was low for all three variables in Oklahoma—birthweight, breastfeeding at discharge, and weight gain during pregnancy were measured for 99.9, 98.2, and 97.0 percent of mother-infant dyads, respectively (Appendix E, Table E.OK.4). In Missouri, the rates of complete cases were somewhat lower, at 99.7, 92.5, and 93.8 percent of mother-infant dyads, respectively (Appendix E, Table E.MO.4). Appendix F shows that results are similar if missing data are imputed.

Unadjusted descriptive statistics show that, in the WM-II sample, adverse birth outcomes were indeed more common among women who participated in WIC in the first trimester than among women who did not participate until later in their pregnancies (Appendix E, Table E.5). Gestational-age bias needs to be eliminated to avoid interpreting these data to mean that early participation in WIC worsens birth outcomes. Not addressing this gestational-age bias could lead to overstated estimates of the association between WIC participation and adverse birth outcomes—that is, women who would have enrolled in WIC late in their pregnancies if they had not delivered prematurely could have driven, at least in part, the rates of adverse birth outcomes among nonparticipants (relative to participants). By extension, gestational-age bias also needs to be addressed for other outcome variables, such as Medicaid costs.

The main approach to controlling for gestational age in WM-II was to use gestational age as a matching variable. This is analogous to using regression models to "control for" gestational age. Specifically, the propensity score models included gestational age (in weeks) and binary indicators of very preterm, preterm, and early term births. Thus, the IPW approach used in the prenatal analysis was designed to compare prenatal WIC participants to a matched comparison group of nonparticipants with the same distribution of gestational age at delivery. (That is, associations between WIC participation and the study outcomes are, in effect, estimated by comparing outcomes for WIC participants and nonparticipants who had deliveries in the same gestational week.) So any differences in outcomes between the prenatal WIC participants and nonparticipants cannot be attributed to differences in gestational age. Exploratory analyses discussed later in this chapter demonstrated that controlling for gestational age is the most important methodological difference between WM-I and WM-II, and largely explains discrepancies between the two studies' results.

However, the approach used to control for gestational age could be conservative, particularly in estimates of the association between WIC participation and the prevalence of preterm births and associated Medicaid costs, if WIC has an effect on gestational age. To address this concern, the study team conducted several exploratory analyses. First, a discrete time hazard model explored the association between WIC participation and gestational age.[31] Second, exploratory analyses assessed associations between *first trimester* WIC participation and the study outcomes using two different econometric specifications. Third, the models were re-estimated using the WM-I specification. These analyses are described in more detail later in this chapter and in Appendix F.

### c. Controlling for multiple comparisons

When multiple hypotheses tests are conducted simultaneously, the statistical significance level—also known as the Type I error rate—is not fixed at 5 percent, but instead increases with the number of tests. This could lead to spurious findings if the *p*-values are not adjusted appropriately (Schochet 2009). As described previously, this concern was the reason the main analysis focused on a limited set of primary outcomes.

[31] Because of the IPW matching approach, which used gestational age as a matching variable, the matched comparison group could not be used to measure differences in preterm birth rates between participants and matched nonparticipants. However, associations between WIC participation and preterm birth were estimated using alternative methods, discussed later in this chapter.

In addition, *p*-values were adjusted for multiple comparisons in domains that included more than one primary outcome. This included the birth outcomes domain (four outcomes), the maternal health domain (two outcomes), and the Medicaid cost domain (two outcomes). Commonly used methods for adjusting for multiple comparisons—including Bonferroni's, Sidak's, and Benjamini and Hochberg's methods—assume that all tests are independent and, thus, yield tests with less statistical power (Schochet 2009). In the prenatal analysis, estimates for outcomes within a domain will almost surely be correlated, because the outcomes themselves are correlated and because treatment effects are heterogeneous. For example, infants who are SGA can also be low or very low birthweight. Thus, if WIC participation affects the proportion of infants born SGA, then WIC participation will probably also affect the proportion born with low or very low birthweight. For this reason, the study team chose a method of adjusting for multiple comparisons that did not assume independence, specifically the method from Hothorn et al. (2008).[32]

### d. Subgroup analyses

Subgroup analyses were conducted to explore associations between WIC participation and the primary outcomes among subgroups defined by mother's age and household income. The methods used for the subgroup analyses were very similar to the methods used for the main analyses. First, the study team divided the sample into two or more subgroups. Then the difference in the primary outcomes between WIC participants and a matched comparison group of nonparticipants was estimated separately for each subgroup. The matched comparison groups of nonparticipants were constructed using IPW. Each propensity score model included gestational age and the full set of matching variables listed in Table III.4. For certain subgroups, some characteristics in the propensity score model were highly correlated or certain characteristics were extremely rare. To accommodate this feature of the data, binary covariates were dropped from the propensity score model when the covariate was observed for fewer than 50 observations in a subgroup. In addition, when two matching variables exhibited near-perfect multicollinearity within a subgroup, one of the two terms was dropped (removing collinear terms is standard practice with regression-based and matching estimators). These adjustments to the data were mainly needed in the smallest subgroups. None of the sensitivity tests that were conducted—such as rerunning the subgroup analyses with and without the adjustments and comparing the IPW-based results to regression-adjusted results—indicated that these minor adjustments affected the results.

Findings for the subgroup analyses should be interpreted with caution. The subgroup analyses were exploratory in nature rather than testing a specific hypothesis, and they did not

[32] This approach requires computing a variance-covariance matrix for all estimated parameters, which in this case include the estimated difference in each outcome between WIC participants and nonparticipants and all coefficients in the propensity score model. The variance-covariance matrix was computed in Stata using a custom program to estimate a system of equations by generalized method of moments. (Newey 1984). This program is based on Cattaneo (2010) and generalized to the case of multiple outcome variables (potentially with different, but overlapping, samples of observations). The variance-covariance matrix was then passed to the R programming language, through which the multiple comparisons adjustment was performed with the software package from Hothorn et al. (2013).

include the controls for multiple comparisons that were included in the main analyses. In addition, sample sizes for some subgroups were small.

## B. Characteristics of WIC participants and nonparticipants

Assessing baseline differences in the observed characteristics of WIC participants and nonparticipants provides insights about underlying unobserved factors that may affect both the decision to participate in WIC and the outcome measures. It also underscores the importance of controlling for differences in observed characteristics when estimating associations between prenatal WIC participation and the outcome measures.

Tables III.5 and III.6 present descriptive statistics for Missouri and Oklahoma, respectively, on baseline (that is *prior to IPW)* demographic, socioeconomic, and health-related characteristics of WIC participants and nonparticipants. Because of the large sample sizes, most baseline differences between characteristics of WIC participants and nonparticipants were statistically significant using a Student's t-test or a chi-squared test, though the differences are relatively small—less than 0.25 standard deviations (SDs) for all variables in Oklahoma and all but two variables in Missouri (rural residence and prenatal care from public clinic).

In both States, the data suggest that WIC participants had a somewhat higher risk of adverse birth outcomes than nonparticipants before IPW was used to construct the matched comparison group. WIC participants tended to be younger than nonparticipants and were more likely to be Hispanic (but less often other racial or ethnic minorities), be unmarried, be foreign born, be from a rural area of the State, and, in Oklahoma, have household incomes below the Federal level. In addition, WIC participants in both States had less education than nonparticipants; attended college at lower rates; received prenatal care from a public clinic more often; and were more often in the aged, blind, and disabled Medicaid enrollment category. In Missouri, WIC participants were more often enrolled in SNAP and less often lived in a county with Medicaid managed care.

The distribution of pre-pregnancy BMIs also differed for WIC participants and nonparticipants, with WIC participants in both States being somewhat more likely to be obese and less likely to have a normal BMI or be underweight (before IPW). In addition, WIC participants in Missouri had higher rates of pre-pregnancy diabetes, were more likely than nonparticipants to have smoked before their pregnancies. On the other hand, WIC participants in one or both States were less likely to have had a prior cesarean delivery, a prior preterm birth, a short inter-pregnancy interval, or a very short inter-pregnancy interval and had, on average, more previous live births and fewer previous terminations.[33]

Comparisons of WIC participants by the trimester they began participating in WIC did not indicate that women who participated in WIC earlier in their pregnancies were at higher or lower risk for poor birth outcomes (before IPW). As shown in the last three columns of Tables III.5 and

[33] WIC participants and nonparticipants were also compared using multivariate analyses that indicate whether a particular characteristic or risk factor is associated with the probability of prenatal WIC participation (the propensity score) holding all other variables constant. For many characteristics, the results from the propensity score model confirmed the results from the univariate comparisons presented in Tables III.5 and III.6. However, there were a few differences (Appendix E, Table E.6).

III.6, there were some differences in the patterns observed between WIC participant and nonparticipants by trimester of enrollment, but the patterns are inconsistent.

### Table III.5. Demographic and socioeconomic characteristics, pregnancy history, and pregnancy risk factors of prenatal WIC participants and nonparticipants in Missouri, before IPW

| Characteristic | Nonparticipants (before IPW) | Prenatal WIC participants | | | |
|---|---|---|---|---|---|
| | | | Trimester WIC participation began | | |
| | | All | First | Second | Third |
| **Mother's characteristics** | | | | | |
| Age | | | | | |
| 17 years or younger | 4.1 | 5.4†† | 4.7†† | 5.5†† | 6.6†† |
| 18 or 19 years | 11.7 | 13.9 | 14.6 | 13.7 | 12.4 |
| 20–34 years | 78.7 | 75.6 | 75.5 | 75.6 | 76.0 |
| 35 years or older | 5.6 | 5.2 | 5.3 | 5.2 | 4.9 |
| Race/ethnicity | | | | | |
| Hispanic | 5.8 | 8.5†† | 7.7†† | 9.8†† | 8.0†† |
| Non-Hispanic white | 62.1 | 64.9 | 72.5 | 59.3 | 58.0 |
| Non-Hispanic black | 25.8 | 20.9 | 14.5 | 25.1 | 27.7 |
| Non-Hispanic American Indian Alaskan Native | 0.2 | 0.3 | 0.3 | 0.3 | 0.2 |
| Non-Hispanic Asian Pacific Islander | 1.9 | 1.2 | 1.0 | 1.3 | 1.7 |
| Non-Hispanic other race | 0.4 | 0.4 | 0.4 | 0.5 | 0.4 |
| Non-Hispanic multirace | 3.0 | 3.1 | 3.0 | 3.1 | 3.5 |
| Race/ethnicity unknown | 0.7 | 0.6 | 0.7 | 0.5 | 0.5 |
| Foreign-born | 7.8 | 9.5** | 8.2 | 11.0** | 9.7** |
| Married | 33.6 | 32.4* | 36.7** | 29.9** | 27.3** |
| Education | | | | | |
| Less than high school | 26.1 | 29.8†† | 29.3†† | 30.3†† | 29.9†† |
| High school grad or GED | 33.3 | 36.5 | 38.1 | 35.5 | 34.7 |
| Some college, no degree | 33.6 | 29.7 | 29.0 | 29.8 | 31.1 |
| College degree | 7.1 | 4.0 | 3.6 | 4.4 | 4.4 |
| Rural residence | 25.7 | 39.8** | 50.9** | 32.4** | 28.2** |
| Prenatal care from public clinic | 20.2 | 39.1** | 45.4** | 35.7** | 30.4** |
| Household income less than 100 percentage of FPL | 87.1 | 87.6 | 86.7 | 88.3** | 88.5** |
| Mean household income (percentage of FPL) | 29.1 | 29.9 | 30.6 | 28.6 | 26.7** |
| SNAP enrollment (mother) | 63.7 | 70.6** | 72.0** | 70.1** | 68.4** |
| SNAP enrollment (infant) | 36.8 | 45.5** | 45.8** | 45.5** | 44.9** |
| TANF enrollment (mother) | 19.4 | 19.4 | 17.5** | 20.5 | 22.1** |
| Aged, blind, and/or disabled Medicaid enrollment (mother) | 2.1 | 3.0** | 3.6** | 2.7** | 2.3 |
| Medicaid managed care beneficiary (mother or infant) | 68.9 | 61.3** | 54.8** | 65.4** | 69.1 |
| **Newborn's characteristics** | | | | | |
| Infant's gender is male | 52.0 | 51.3 | 51.0 | 51.5 | 51.4 |

Table III.5. (*continued*)

| Characteristic | Nonparticipants (before IPW) | Prenatal WIC participants | | | |
|---|---|---|---|---|---|
| | | | Trimester WIC participation began | | |
| | | All | First | Second | Third |
| **Pregnancy risk factors** | | | | | |
| Pre-pregnancy BMI | | | | | |
| Less than 18.5 (underweight) | 5.6 | 5.4†† | 5.5†† | 5.5†† | 5.1†† |
| 18.5 to 24.9 (normal) | 47.8 | 41.4 | 39.2 | 42.7 | 44.0 |
| 25 to 29.9 (overweight) | 22.6 | 22.7 | 22.5 | 23.0 | 22.7 |
| 30 to 40.4 (obese) | 17.5 | 21.9 | 23.5 | 20.7 | 20.1 |
| 40.5 or more (extremely obese) | 4.2 | 6.2 | 7.3 | 5.5 | 5.2 |
| Unknown | 2.2 | 2.4 | 1.9 | 2.7 | 3.0 |
| Smoked three months before pregnancy | 35.8 | 38.0** | 40.5** | 35.9 | 36.1 |
| Number of cigarettes/day before pregnancy | 6.5 | 6.0** | 7.1** | 6.1 | 6.1 |
| Previous cesarean delivery | 12.9 | 12.0* | 11.5** | 12.2 | 12.7 |
| Previous preterm birth | 4.1 | 3.4** | 3.3** | 3.5* | 3.1** |
| Previous other poor birth outcomes | 1.7 | 1.9 | 2.2** | 1.7 | 1.6 |
| Pre-pregnancy diabetes | 0.7 | 1.0** | 1.2** | 1.0* | 0.7 |
| Pre-pregnancy hypertension | 1.4 | 1.6 | 1.9** | 1.5 | 1.2 |
| **Pregnancy history** | | | | | |
| Inter-pregnancy interval | | | | | |
| First birth | 29.6 | 35.6†† | 39.3†† | 33.0†† | 32.2†† |
| ≥ 18 months | 31.6 | 29.2 | 28.2 | 28.8 | 32.3 |
| Short (6–17 months) | 16.9 | 15.8 | 14.9 | 16.9 | 15.6 |
| Very short (< 6 months) | 8.8 | 7.9 | 6.4 | 9.4 | 8.8 |
| Unknown | 13.2 | 11.5 | 11.3 | 11.9 | 11.0 |
| Number of previous live births (mean) | 1.1 | 1.3** | 1.0** | 1.2** | 1.2** |
| Any previous terminations | 27.5 | 26.5* | 25.8** | 27.2 | 26.7 |
| **Sample size** | **11,134** | **26,703** | **11,884** | **9,939** | **4,880** |

Source: WM-II database for Missouri, constructed by Mathematica Policy Research.

Notes: Based on Medicaid-covered births in Missouri from April 2010 to March 2011 linked with a Vital Records birth certificate.

The table presents the percentage of observations for binary and categorical variables, as well as means for continuous variables. Table III.4 defines the variables. Asterisks denote statistically significant differences between WIC participants and nonparticipants from Student's t-tests for dichotomous and continuous variables (*$p < 0.05$; **$p < 0.01$), and daggers denote statistically significant chi-squared tests for categorical variables (†$p < 0.05$; ††$p < 0.01$). Because of rounding and missing data, percentages across categories might not total 100 percent.

See Appendix D for comparisons of WIC participants and nonparticipants after IPW.

Data on mother's age, rural residence, infant's gender, and mother's education were missing for 8, 6, 1, and 168 births, respectively. Because so few observations were missing data for these variables, the missing data category was combined with the mode.

BMI = body mass index; FPL = Federal poverty level; GED = general educational development (diploma); IPW = inverse probability weighting; SNAP = Supplemental Nutrition Assistance Program; TANF = Temporary Assistance for Needy Families; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

As described in Section A.3.a, the study team used IPW methods to construct a matched comparison group that greatly reduced, and often eliminated, baseline differences between WIC participants and nonparticipants. Appendix D describes the IPW methods and results in detail.

**Table III.6. Demographic and socioeconomic characteristics, pregnancy history, and pregnancy risk factors of prenatal WIC participants and nonparticipants in Oklahoma, before IPW**

| Characteristic | Nonparticipants (before IPW) | Prenatal WIC participants | | | |
|---|---|---|---|---|---|
| | | | Trimester WIC participation began | | |
| | | All | First | Second | Third |
| **Mother's characteristics** | | | | | |
| Age | | | | | |
| 17 years or younger | 3.7 | 6.2†† | 5.6†† | 6.4†† | 7.2†† |
| 18 or 19 years | 9.3 | 13.8 | 14.7 | 13.2 | 13.1 |
| 20–34 years | 80.7 | 74.7 | 74.8 | 74.4 | 75.0 |
| 35 years or older | 6.2 | 5.3 | 4.9 | 6.0 | 4.7 |
| Race/ethnicity | | | | | |
| Hispanic | 13.1 | 20.3†† | 16.7†† | 24.2†† | 20.5†† |
| Non-Hispanic white | 53.2 | 53.5 | 60.2 | 48.3 | 48.2 |
| Non-Hispanic black | 12.7 | 10.1 | 7.3 | 11.3 | 14.1 |
| Non-Hispanic American Indian Alaskan Native | 12.6 | 9.6 | 10.0 | 9.4 | 9.3 |
| Non-Hispanic Asian Pacific Islander | 2.8 | 1.7 | 0.9 | 2.1 | 2.5 |
| Non-Hispanic other race | 0.2 | 0.3 | 0.1 | 0.4 | 0.4 |
| Non-Hispanic multirace | 5.4 | 4.7 | 4.9 | 4.4 | 4.9 |
| Foreign-born | 11.8 | 16.2** | 12.4 | 20.3** | 16.7** |
| Married | 42.0 | 38.9** | 41.7 | 37.9** | 34.3** |
| Education | | | | | |
| Less than high school | 27.8 | 33.2†† | 31.2†† | 35.2†† | 33.7†† |
| High school grad or GED | 33.2 | 36.3 | 38.7 | 34.5 | 34.4 |
| Some college, no degree | 32.2 | 26.8 | 26.6 | 26.3 | 28.0 |
| College degree | 6.5 | 3.5 | 3.2 | 3.8 | 3.7 |
| Unknown | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| Rural residence | 34.9 | 44.8** | 55.4** | 37.5** | 34.7 |
| Prenatal care from public clinic | 5.3 | 11.2** | 11.3** | 12.4** | 8.4** |
| Household income less than 100 percent of FPL | 79.2 | 81.1** | 80.5* | 81.4** | 81.8** |
| Mean household income (percentage of FPL) | 52.0 | 51.5 | 53.7 | 52.3 | 46.9** |
| TANF enrollment (mother) | 19.1 | 19.6 | 18.3* | 20.0 | 22.1** |
| Aged, blind, and/or disabled Medicaid enrollment (mother) | 0.2 | 0.5** | 0.5** | 0.7** | 0.4 |
| **Newborn's characteristics** | | | | | |
| Infant's gender is male | 50.6 | 51.4 | 51.5 | 51.5 | 51.2 |

Table III.6. (*continued*)

| | | Prenatal WIC participants | | | |
|---|---|---|---|---|---|
| | | | Trimester WIC participation began | | |
| **Characteristic** | **Nonparticipants (before IPW)** | **All** | **First** | **Second** | **Third** |
| **Pregnancy risk factors** | | | | | |
| Pre-pregnancy BMI | | | | | |
| Less than 18.5 (underweight) | 5.7 | 5.1†† | 5.0†† | 5.0†† | 5.5 |
| 18.5 to 24.9 (normal) | 45.2 | 41.4 | 38.7 | 42.2 | 46.2 |
| 25 to 29.9 (overweight) | 24.7 | 24.2 | 23.2 | 24.9 | 24.9 |
| 30 to 40.4 (obese) | 18.6 | 22.2 | 24.8 | 21.2 | 18.1 |
| 40.5 or more (extremely obese) | 4.6 | 5.9 | 7.2 | 5.3 | 4.0 |
| Unknown | 1.3 | 1.3 | 1.2 | 1.4 | 1.3 |
| Smoked three months before pregnancy | 16.6 | 16.1 | 17.6* | 14.7** | 15.2 |
| Number of cigarettes/day before pregnancy | 1.9 | 1.9 | 2.1* | 1.7* | 1.7 |
| Previous cesarean delivery | 15.4 | 14.5* | 14.5 | 14.6 | 14.2 |
| Previous preterm birth | 2.4 | 2.1 | 2.1 | 2.1 | 2.0 |
| Previous other poor birth outcomes | 1.3 | 1.4 | 1.7 | 1.1 | 1.3 |
| Pre-pregnancy diabetes | 0.7 | 0.9 | 1.0* | 0.8 | 0.6 |
| Pre-pregnancy hypertension | 1.2 | 1.5 | 1.8** | 1.4 | 1.0 |
| **Pregnancy history** | | | | | |
| Inter-pregnancy interval | | | | | |
| First birth | 26.7 | 36.8†† | 39.6†† | 34.8†† | 34.2†† |
| ≥8 months | 37.2 | 33.5 | 33.3 | 33.9 | 33.3 |
| Short (6–17 months) | 19.8 | 16.3 | 15.8 | 16.3 | 17.4 |
| Very short (< months) | 10.4 | 7.9 | 6.1 | 9.4 | 9.1 |
| Unknown | 6.0 | 5.5 | 5.3 | 5.6 | 6.0 |
| Number of previous live births (mean) | 1.1 | 1.4** | 1.0** | 1.2** | 1.2** |
| Any previous terminations | 20.9 | 20.1 | 20.3 | 19.5* | 20.5 |
| **Sample size** | **8,145** | **22,537** | **9,825** | **9,656** | **4,056** |

Source: WM-II database for Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid-covered births in Oklahoma from February 2010 to January 2011 linked with a Vital Records birth certificate.

The table presents the percentage of observations for binary and categorical variables, as well as means for continuous variables. Table III.4 defines the variables. Asterisks denote statistically significant differences between WIC participants and nonparticipants from Student's t-tests for dichotomous and continuous variables (*$p < 0.05$; **$p < 0.01$), and daggers denote statistically significant chi-squared tests for categorical variables (†$p < 0.05$; ††$p < 0.01$). Because of rounding and missing data, percentages across categories might not total 100 percent.

See Appendix D for comparisons of WIC participants and nonparticipants after IPW.

Data on household income, number of prior other birth outcomes, and rural residence were missing for 25, 2, and 75 births, respectively. Because so few observations were missing data for these variables, the missing data category was combined with the mode.

BMI = body mass index; FPL = Federal poverty level; GED = general educational development (diploma); IPW = inverse probability weighting; TANF = Temporary Assistance for Needy Families; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

## C. Associations between prenatal WIC participation and study outcomes

### 1. Birth outcomes

In both Missouri and Oklahoma, there were no statistically significant differences between WIC participants (who participated at any time during their pregnancy) and the matched comparison group of nonparticipants in the prevalence of **low birthweight**, **very low birthweight**, or **SGA** births, or in the rate of **neonatal infant mortality** (Figure III.1).[34]

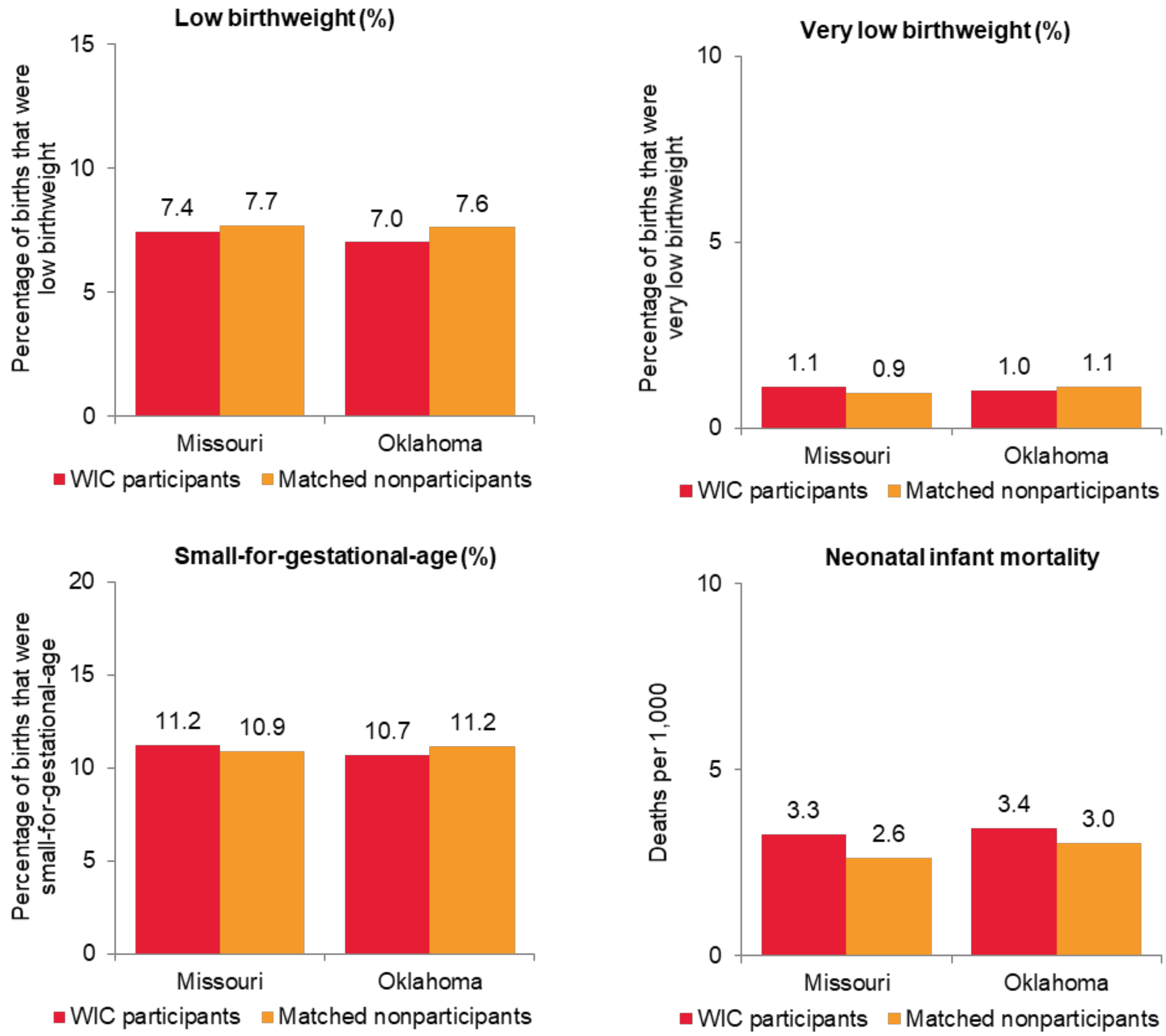
About 7.4 percent of infants born to WIC participants in Missouri were **low birthweight** (fewer than 2,500 grams), compared with 7.7 percent of infants born to nonparticipants in the matched comparison group. In Oklahoma, about 7.0 percent of infants born to WIC participants were low birthweight, whereas 7.6 percent of infants born to nonparticipants in the matched comparison group were low birthweight. In Missouri, the rate of **very low birthweight** (fewer than 1,500 grams) births was 1.1 percent among WIC participants compared to 0.9 percent among the matched nonparticipants, whereas in Oklahoma the rate of very low birthweight births was 1.0 percent among WIC participants and 1.1 percent among the matched nonparticipants. None of these differences were large (differences were all less than 0.02 SD) or statistically significant.

These results reflect the challenge of analyzing outcome measures that are largely determined by the length of gestation while at the same time adjusting for gestational-age bias. Here, the two birthweight measures are closely related to length of gestation—preterm births are often low birthweight—while length of gestation was used as a matching variable to address the concern of gestational-age bias (Section A.3.b). Therefore, it might be unsurprising that there are no significant differences in the prevalence of low and very low birthweight between WIC participants and the matched nonparticipants *with the same gestational age.*

However, differences between the birth outcomes of WIC participants and matched nonparticipants might be attenuated if WIC participation is associated with longer gestational lengths. The study team conducted exploratory analyses to assess the association between prenatal WIC participation and gestational age, and identified some differences between WIC participants and nonparticipants. The box on page 52 describes the exploratory analyses, key findings, and implications for interpreting WM-II findings on birth outcomes.

[34] Appendix E, Table E.7 presents detailed findings for all the primary outcomes, including the mean outcome for WIC participants and matched nonparticipants, the difference in means, SEs, effect-sizes, and sample sizes.

**Figure III.1. Estimates of the association between any prenatal WIC participation and the primary birth outcomes**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid-covered births in Missouri from April 2010 to March 2011 and in Oklahoma from February 2010 to January 2011 linked with a Vital Records birth certificate. Some observations were dropped, on a variable-by-variable basis, because of missing data. Refer to Appendix E, Table E.4 for sample sizes.

Table III.3 defines outcomes. The low birthweight and very low birthweight outcome measures are binary indicators of birthweight fewer than 2,500 g and fewer than 1,500 g, respectively. SGA infants had birthweights below the 10th percentile for gestational age based on race-, ethnicity-, and gender-specific reference standards. Neonatal infant mortality includes infant deaths occurring fewer than 28 days after birth. Lower than [higher than] recommended weight gain during pregnancy are weight gains 10 percent or more below [above] the IOM recommendations.

The matched comparison group of nonparticipants was constructed with IPW, as described in the text. The propensity score model included gestational age and the full set of covariates shown in Table III.4.

None of the differences between WIC participants and nonparticipants were statistically significant at the $p < .05$ level. Statistical tests for the differences between WIC participants and nonparticipants were adjusted for multiple comparisons using methods from Hothorn et al. (2008, 2013).

IOM = Institute of Medicine; IPW = inverse probability weighting; SGA = small-for-gestational-age; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

**Associations between prenatal WIC participation and gestational age, and implications for interpreting the main WM-II analyses**

The IPW methods used in the main analyses discussed in Section C adjust for differences between WIC participants and nonparticipants in gestational age. Controlling for gestational age in this manner addresses concerns about gestational-age bias. However, this approach could attenuate estimates of the association between prenatal WIC participation and the various outcome measures if WIC participation affects gestational age. To address this issue, a discrete time hazard model was estimated to assess the association between WIC participation and gestational age (length of gestation). The hazard model enabled assessment of the association between WIC participation and gestational lengths while avoiding gestational-age bias. Methods and detailed results are presented in Appendix F.

The discrete time hazard model revealed some differences between WIC participants and matched nonparticipants in the probability of delivering in certain stages of pregnancy. Most importantly, the discrete time hazard model indicated that the probability of a preterm birth could be reduced by as much as 1.03 percentage points for a woman in Oklahoma who began participating in WIC at the very beginning of her pregnancy, compared to risk of a preterm birth if she did not participate in WIC at all. (This is an upper bound estimate because most women do not begin participating in WIC until later in their pregnancies. It represents a statistically significant 9.3 percent reduction, or a risk ratio of 0.91, $p$=0.023) The pattern was similar in Missouri—a reduction of 0.68 percentage points in the probability of a preterm birth (a 7.2 percent reduction, or a risk ratio of 0.93)—but the difference between WIC participants and matched nonparticipants was not statistically significant at $p < 0.05$ ($p$=0.057).

The estimated reductions in the probability of preterm birth obtained from the discrete time hazard models are smaller than those estimated in previous research that did not adjust for gestational-age bias. This finding suggests the difference in average gestational lengths between WIC participants and nonparticipants is, to a large extent, driven by gestational-age bias (not impacts of WIC on gestational age). To some degree, this finding justifies the decision to adjust for gestational-age bias in the main WM-II analyses. Nonetheless, readers should use caution when interpreting results of the main analyses reported in Section C (that is, the estimated associations between prenatal WIC participation and the study outcomes, which adjusted for gestational age). Differences in outcomes between WIC participants and matched nonparticipants might be attenuated if, in fact, WIC participation is associated with longer gestational lengths, as shown in the hazard model analysis. For example, mean birthweight for infants of WIC participants would likely have been higher, relative to the matched nonparticipants, if the main analysis had not controlled for differences in gestational age between the two groups. That is, the main WM-II analyses (which adjusted for gestational age at birth) may have been conservative, yet unadjusted analyses almost certainly over-estimate the association between prenatal WIC participation and birth outcomes (Joyce et al. 2008; Fingar et al. 2017). More research is needed to assess the degree to which the main results might be attenuated, but there is reason to believe that the main results could be less biased than results from an analysis that did not address gestational-age bias, such as WM-I.

The analysis also examined the prevalence of **SGA births**—a measure of fetal growth that gestational-age bias cannot affect by definition. In both States, WIC participants and nonparticipants had similar rates of SGA births, and differences were not statistically significant. In Missouri, 11.2 percent of births to prenatal WIC participants were SGA, compared with 10.9 percent of births to matched nonparticipants. In Oklahoma, 10.7 percent of births to prenatal WIC participants were SGA, compared with 11.2 percent of births to matched nonparticipants. These differences are small (less than 0.02 SD) and were not statistically significant.

In both States, rates of **neonatal infant mortality**, defined as infant deaths occurring fewer than 28 days after birth, were not significantly different between WIC participants and the matched nonparticipants. In Missouri, the rates of neonatal infant mortality were 3.3 and 2.6 deaths per 1,000 for WIC participants and nonparticipants, respectively. In Oklahoma the rates were 3.4 and 3.0 deaths per 1,000 for WIC participants and matched nonparticipants, respectively. These differences are small (0.012 SD or smaller) and were not statistically significant.

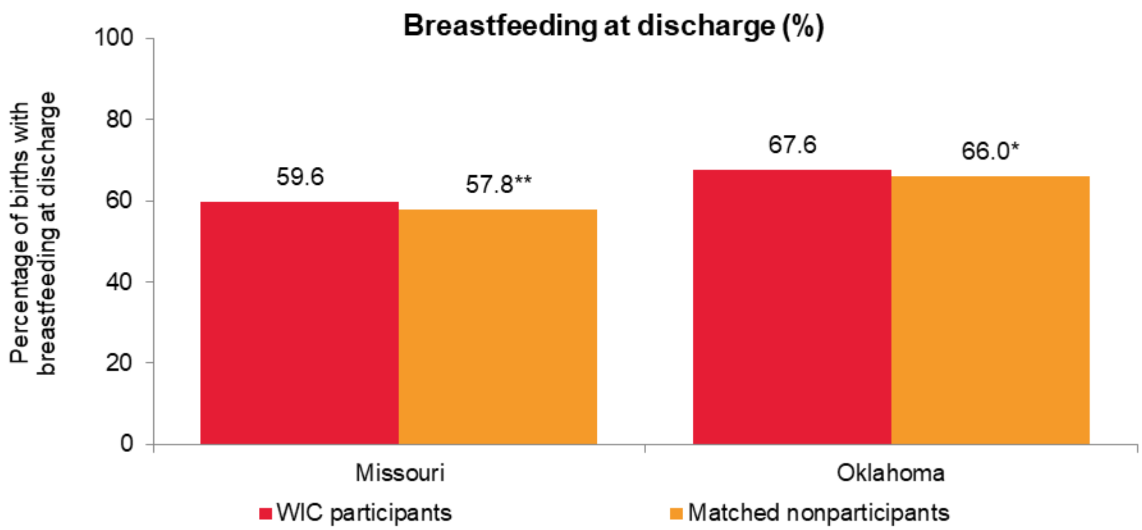
Exploratory analyses with the **secondary birth outcome measures** using samples matched on gestational-age confirm the main findings—there were no statistically significant differences in either State between WIC participants and nonparticipants for any of the birthweight, fetal growth, and infant mortality outcome measures examined (Appendix E, Table E.8).

### 2. Maternal behaviors

WIC participants in both States were significantly more likely than matched nonparticipants to be **breastfeeding** their infants at discharge. The breastfeeding rate for WIC participants in Missouri was 59.6 percent at discharge, compared with 57.8 percent for the matched nonparticipants, whereas in Oklahoma the breastfeeding rate for WIC participants was 67.6 percent, compared with 66.0 percent for matched nonparticipants (Figure III.2). The differences between the WIC participants and the matched nonparticipants of 1.9 percentage points in Missouri and 1.6 percentage points in Oklahoma—though statistically significant—were relatively small (about 0.038 and 0.034 SD, respectively). These findings are inconsistent with the bulk of existing literature on the association between WIC participation and breastfeeding, which suggest lower rates of breastfeeding among WIC participants (Colman et al. 2012). This inconsistency might be due to a difference in the populations under study—in WM-II, both the participant and nonparticipant groups include only Medicaid recipients—or to differences in strategies used to control for selection bias. The positive findings for breastfeeding initiation are particularly interesting given that the revised WIC food packages include options designed to encourage and support breastfeeding (U.S. Department of Agriculture, Food and Nutrition Service 2009).

Exploratory analyses with the **secondary maternal behaviors outcome** measures did not find any statistically significant associations between prenatal WIC participation and smoking during pregnancy (Appendix E, Tables E.9 and E.10). However, WIC participants were 6.7 to 9.2 percentage points more likely than nonparticipants to receive adequate prenatal care, depending on the State and the measure used (Appendix E, Table E.9). These differences were statistically significant but should be interpreted with caution, given the more exploratory nature of the analysis (controls for multiple comparisons were not included) and the fact that WIC participants sometimes initiated prenatal care before participating in WIC (before WIC could have encouraged them to initiate prenatal care), particularly among those who participated in WIC in the first trimester (Appendix E, Table E.11).

**Figure III.2. Estimates of the association between any prenatal WIC participation and breastfeeding at discharge**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid-covered births in Missouri from April 2010 to March 2011 and in Oklahoma from February 2010 to January 2011 linked with a Vital Records birth certificate. Some observations were dropped due to missing data on breastfeeding. Refer to Appendix E, Table E.4 for sample sizes.

The outcome measure is a binary indicator of whether the newborn was breastfed at discharge, as reported on the birth certificate.

The matched comparison group of nonparticipants was constructed with IPW, as described in the text. The propensity score model included gestational age and the full set of covariates shown in Table III.4.

* Difference is statistically significant at the $p < 0.05$ level.

** Difference is statistically significant at the $p < 0.01$ level.

IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

### 3. Maternal health

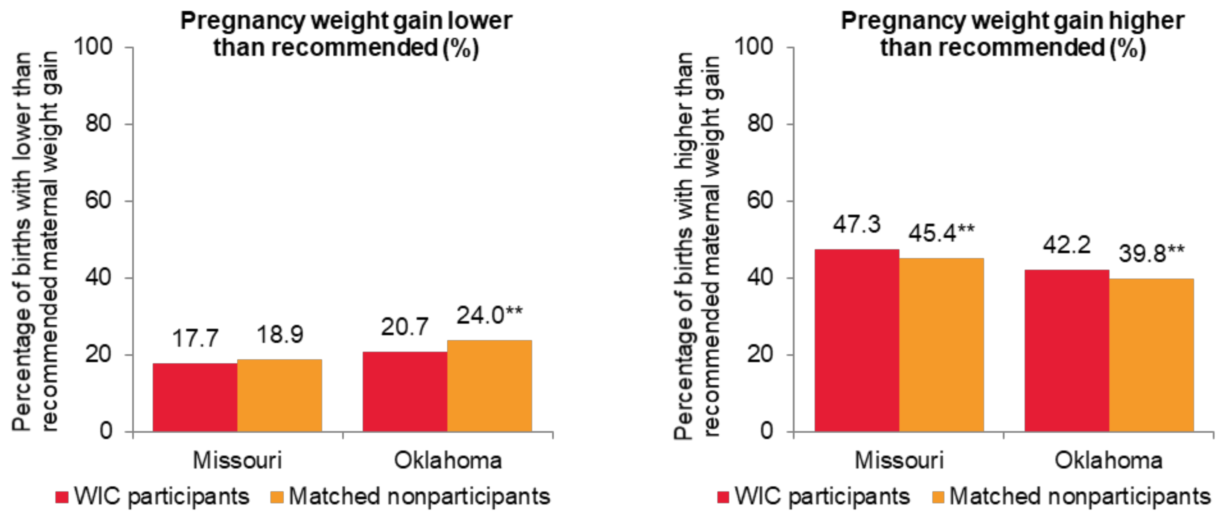
In Oklahoma, WIC participants were significantly less likely than matched nonparticipants to have **lower-than-recommended weight gain** during their pregnancies. In both Missouri and Oklahoma, WIC participants were more likely to have **higher-than-recommended weight gain** (Figure III.3). The differences in the rates of higher-than-recommended weight gain between the participants and nonparticipants of 2.0 percentage points in Missouri and 2.4 percentage points in Oklahoma were statistically significant, as was the difference of 3.1 percentage points in the rate of lower-than-recommended weight gain in Oklahoma.[35] These differences were small (no larger than 0.08 SD). Because the differences for these two measures have opposite signs (in both

[35] Exploratory subgroup analyses indicated that the association between WIC participation and recommended weight gain was not influenced by pre-pregnancy weight status. In both Missouri and Oklahoma, this association was observed among women who were normal weight or underweight at the beginning of their pregnancy, as well as among women who were overweight or obese. With one exception (women in Missouri who were overweight or obese at the start of their pregnancy), all of the associations were statistically significant.

States), there were no statistically significant differences, on net, in either State between the percentage of WIC participants and matched nonparticipants who had an appropriate weight gain during pregnancy (that is, a weight gain that neither fell below nor exceeded the ranges recommended by the IOM).

Exploratory analyses with **secondary maternal health outcome** measures did not identify statistically significant differences between WIC participants and nonparticipants in either State (Appendix E, Table E.12).

**Figure III.3. Estimates of the association between any prenatal WIC participation and maternal weight gain**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid-covered births in Missouri from April 2010 to March 2011 and in Oklahoma from February 2010 to January 2011 linked with a Vital Records birth certificate. Some observations were dropped because of missing data for maternal weight gain. Refer to Appendix E, Table E.4 for sample sizes.

The outcome measures are binary indicators of pregnancy weight gain that was 10 percent below or more than 10 percent above the IOM recommendations.

The matched comparison group of nonparticipants was constructed with IPW, as described in the text. The propensity score model included gestational age and the full set of covariates shown in Table III.4.

Statistical tests for the differences between WIC participants and nonparticipants were adjusted for multiple comparisons using methods from Hothorn et al. (2008, 2013).

** Difference is statistically significant at the $p < 0.01$ level.

IOM = Institute of Medicine; IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

## 4. Medicaid costs

Two measures were used to explore the association between prenatal WIC participation and Medicaid costs: (1) **Medicaid costs from birth through 60 days postpartum** and (2) **Medicaid costs from the prenatal period through 60 days postpartum**. The first is comparable to the measure used in WM-I, and the second includes all the costs in the first measure plus any of the mother's costs during the prenatal period.[36] Thus, the second measure assesses total Medicaid costs associated with a pregnancy and birth. This expanded measure of Medicaid costs is of interest because WIC promotes access to prenatal care through referral to appropriate medical practitioners, and Medicaid can cover some of these services.[37]

As noted in Chapter II, there are limitations to the analysis of Medicaid costs in both States because cost data were not available for all mothers and infants. In Missouri, the analysis is limited to fee-for-service Medicaid recipients (those not enrolled in Medicaid managed care), which is approximately one-third of the sample. In Oklahoma, the analysis excludes Native Americans.[38] Further, differences between the Medicaid costs of WIC participants and matched nonparticipants might be attenuated if WIC participation is associated with longer gestational lengths (see page 52).

### a. Medicaid costs from birth through 60 days postpartum

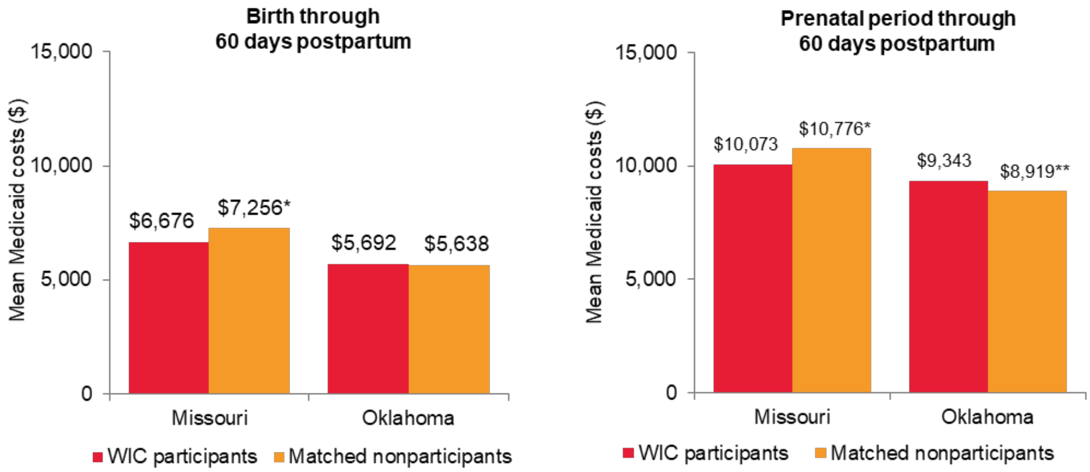
Prenatal WIC participants had lower fee-for-service **Medicaid costs from birth through 60 days postpartum** than matched nonparticipants in Missouri, but not Oklahoma (Figure III.4). In Missouri, average Medicaid costs from birth through 60 days postpartum were $6,676 for WIC participants and $7,256 for the matched comparison group. The difference of $580 was statistically significant. In Oklahoma, Medicaid costs for this period were similar for WIC participants and the matched comparison group ($5,692 versus $5,638) and the difference between the two groups was not statistically significant.

[36] In an addendum to the WM-I study, Medicaid costs were extended through one year postpartum (Devaney et al. 1991). The WM-II database does not include Medicaid costs past the first 60 days postpartum.

[37] Indeed, analyses of secondary outcomes found that WIC participants in both States were more likely than matched nonparticipants to receive adequate prenatal care. See Section C.2 and Appendix E, Table E.9. Analyses of secondary outcomes were not adjusted for multiple comparisons, so findings must be interpreted with caution and should be considered exploratory. As noted in Section C.2, this association may not be a causal relationship; some WIC participants initiated prenatal care before enrolling in WIC.

[38] Section D.4 and Appendix F discuss robustness checks conducted to assess the implications of these data limitations.

**Figure III.4. Estimates of the association between any prenatal WIC participation and Medicaid costs**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on all Medicaid-covered births in Missouri from April 2010 to March 2011 and in Oklahoma from February 2010 to January 2011 linked with a Vital Records birth certificate. Refer to Appendix E, Table E.4 for sample sizes.

In the first panel, the outcome measure is a continuous measure of costs for mothers' labor and delivery and other medical care through 60 days postpartum and costs for newborns at birth and through 60 days postpartum (from fee-for-service Medicaid claims). In the second panel, the outcome measure is a continuous measure of costs for mothers' prenatal care, labor and delivery, and other medical care through 60 days postpartum and costs for newborns at birth and through 60 days postpartum (from fee-for-service Medicaid claims).

The matched comparison group of nonparticipants was constructed with IPW, as described in the text. The propensity score model included gestational age and the full set of covariates shown in Table III.4.

The analysis of Medicaid costs in Missouri includes only fee-for-service recipients. About 64 percent of Medicaid recipients in Missouri are enrolled in Medicaid managed care and were excluded from the analysis because managed care claims in Missouri do not include information about actual costs of services.

The analysis of Medicaid costs in Oklahoma excludes Native Americans, accounting for approximately 17 percent of the sample. Oklahoma Medicaid did not provide cost data for Native Americans, because many of them receive care through the IHS, whose providers do not necessarily report all services and costs to Oklahoma Medicaid.

Statistical tests for the differences between WIC participants and nonparticipants were adjusted for multiple comparisons using methods from Hothorn et al. (2008, 2013).

* Difference is statistically significant at the $p < 0.05$ level.

** Difference is statistically significant at the $p < 0.01$ level.

IHS = Indian Health Service; IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

The study team conducted exploratory analyses with a variety of disaggregated Medicaid cost and health care utilization measures to better understand these findings.[39] In Missouri, the lower Medicaid costs from birth through 60 days postpartum were mainly attributable to lower inpatient costs for infants of prenatal WIC participants, relative to infants in the matched comparison group. WIC infants in Missouri spent fewer days in the hospital at birth (on average) than infants in the matched comparison group and were less likely to be admitted to the neonatal intensive care unit (NICU) (regardless of gestational age). In Oklahoma, the measures of Medicaid costs and health care utilization were generally consistent for WIC participants and the matched comparison group. WIC participation was associated with somewhat higher non-inpatient Medicaid costs for mothers, but this was offset by slightly lower costs for other subcategories of Medicaid services. Therefore, on net and as shown in Figure III.4, there was no statistically significant association between prenatal WIC participation and Medicaid costs in Oklahoma for mothers and infants (combined) from birth through 60 days postpartum. In Oklahoma, there were no significant differences between WIC participants and matched nonparticipants in the use of inpatient services (for either mothers or infants), but prenatal WIC participants and their infants had increased utilization of all types of outpatient services explored in the analysis.

**b. Medicaid costs from the prenatal period through 60 days postpartum**

In both Missouri and Oklahoma, there was a statistically significant association between prenatal WIC participation and the expanded measure of **Medicaid costs from the prenatal period through 60 days postpartum**, but the direction of the difference was inconsistent. As with the previous measure of Medicaid costs, prenatal WIC participation in Missouri was associated with lower Medicaid costs. Average Medicaid costs for the prenatal period through 60 days postpartum were $10,073 for WIC participants and $10,776 for the matched comparison group, and the difference of $703 was statistically significant (Figure III.4). This association between WIC participation and Medicaid costs compares favorably with average prenatal WIC costs.[40] In Oklahoma, on the other hand, Medicaid costs from the prenatal period through 60 days postpartum were $424 *higher* for WIC participants than for the matched comparison group ($9,343 versus $8,919). This difference was also statistically significant.

Thus, in Missouri, prenatal WIC participation was consistently associated with significantly lower Medicaid costs, regardless of whether costs during the prenatal period are included. In Oklahoma, there was no association between prenatal WIC participation and Medicaid costs when Medicaid costs included only the period from birth through 60 days postpartum. However,

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[39] See Appendix E, Tables E.2, E.13 and E.14 for analyses of exploratory Medicaid cost and health care utilization measures. Appendix F discusses additional analyses that were conducted to explore why the infants of WIC participants in Missouri might have had lower NICU admission rates and lower inpatient Medicaid costs than matched nonparticipants even though the main findings—both overall and for the fee-for-service population alone—do not indicate that these infants had better birth outcomes. The exploratory analyses were not adjusted for multiple comparisons, so findings must be interpreted with caution.

[40] In Missouri, average food costs for prenatal WIC participants were $188. Applying an adjustment factor of 1.48 to account for administrative and nutrition education costs from 2009 to 2011 (U.S. Department of Agriculture, Food and Nutrition Service 2014) yields an estimate of average prenatal WIC costs equal to $278 per prenatal WIC participant.

WIC participation in Oklahoma was associated with *higher* Medicaid costs when costs for the prenatal period were added. Exploratory analyses, found that this was largely attributable to Medicaid costs for non-inpatient services during the prenatal period being higher for WIC participants than for the matched comparison group.[41] WIC participants in Oklahoma had more office and ER visits during the prenatal period than the matched comparison group and, as noted above, were more likely than matched nonparticipants to receive adequate prenatal care.

## D. Supplemental analyses

The study team conducted a number of supplemental analyses to explore secondary questions about the associations between prenatal WIC participation and the various outcomes. The analyses examined these associations by trimester of enrollment, by length of participation, and among subgroups of women defined by mother's age and household income.

### 1. Estimates by trimester of WIC enrollment

These analyses explored whether enrolling in WIC earlier during pregnancy was associated with better outcomes, relative to later enrollment. The sample of WIC participants was separated into three groups based on the trimester they began participating in WIC (Table III.1), and a matched comparison group of nonparticipants was constructed for each group using IPW. Table III.7 presents the results. Given the more exploratory nature of these analyses, and the fact that controls for multiple comparisons were not included, the results should be interpreted with caution.

The associations between trimester of WIC participation and breastfeeding and higher than recommended weight gain appears to be the two cases with the strongest "dose response" relationship. For these two outcomes, the associations are consistent with the main findings, similar in direction and magnitude in both States, and both States exhibit a monotonic relationship with trimester of WIC participation. That is, the association is stronger for WIC participants who began participating earlier in their pregnancies. (This pattern also occurred for Medicaid costs in Oklahoma, but not in Missouri.)

In Missouri, the results for women who participated in WIC in the first trimester largely confirm the main findings reported in Section C—the point estimates for all outcome measures are in the same direction and of roughly the same magnitude (Table III.7, column 1). For these women, associations between first trimester WIC participation and the percentage of women breastfeeding at discharge and with higher-than-recommended pregnancy weight gains were in the favorable direction and statistically significant. The differences in average Medicaid costs between first-trimester WIC participants and their matched comparison group was not statistically significant for one of the two Medicaid cost measures, but both point estimates were within 10 percent of the corresponding estimates for all WIC participants (in Figure III.4). In Missouri, however, the findings for second- and third-trimester WIC participants were not consistently smaller than the estimates for first-trimester WIC participants (Table III.7, columns 2 and 3). In particular, the estimates for WIC participants who began participation in the third

[41] See Appendix E, Tables E.2, E.13 and E.14 for analyses of exploratory Medicaid cost and health care utilization measures. Analyses of exploratory outcomes were not adjusted for multiple comparisons, so findings must be interpreted with caution.

trimester in Missouri were less comparable and sometimes even had the opposite sign. The estimate for higher-than-recommended pregnancy weight gain is 2.3 percentage points for both first- and second-trimester participants, respectively, but 1.1 percentage points for third-trimester participants.

In Oklahoma, the results for women who participated in WIC in the first trimester also largely confirm the main findings presented earlier (Table III.7, column 4). As mentioned above, the point estimates in Oklahoma indicate larger associations between WIC participation and low birthweight births, maternal weight gain, and Medicaid costs. Notably, the result for low birthweight was statistically significant for first trimester WIC participants (unlike the results above for all WIC participants). The magnitude of the point estimates for second- and third-trimester WIC participants in Oklahoma was smaller than the estimates for first-trimester WIC participants for the two maternal weight gain measures and Medicaid costs. The difference in Medicaid costs (from the prenatal period through 60 days postpartum) between WIC participants and nonparticipants decreases monotonically from +$599 for first trimester participants to +$330 and −$42 dollars for second- and third-trimester participants, respectively (Table III.7, columns 4 through 6). If WIC is truly associated with increased prenatal costs, and the association is larger for women with more exposure to WIC, this finding could be consistent with the secondary analyses presented earlier that showed prenatal WIC participation was associated with higher Medicaid spending in the prenatal period (on average). Patterns for the maternal weight gain measures were similar—larger for first-trimester participants than for second- and third-trimester participants.

## Table III.7. Estimates of the association between prenatal WIC participation and the primary outcomes, by State and trimester of WIC enrollment

| | Missouri | | | Oklahoma | | |
|---|---|---|---|---|---|---|
| | WIC participation began in first trimester | WIC participation began in second trimester | WIC participation began in third trimester | WIC participation began in first trimester | WIC participation began in second trimester | WIC participation began in third trimester |
| Outcome | (1) | (2) | (3) | (4) | (5) | (6) |
| **Birth outcomes** | | | | | | |
| Low birthweight (%) | −0.07<br>(0.39) | −0.50<br>(0.31) | −0.39<br>(0.35) | -1.25**<br>(0.43) | -0.17<br>(0.36) | -0.23<br>(0.38) |
| Very low birthweight (%) | 0.25*<br>(0.10) | 0.11<br>(0.08) | -0.04<br>(0.07) | -0.26<br>(0.13) | -0.06<br>(0.10) | -0.07<br>(0.08) |
| Small-for-gestational-age (%) | 0.64<br>(0.54) | 0.15<br>(0.45) | 1.50<br>(0.55) | -0.74<br>(0.58) | -0.65<br>(0.54) | 0.20<br>(0.63) |
| Neonatal mortality (deaths per 1,000) | 1.07<br>(0.78) | 0.37<br>(0.70) | -0.23<br>(0.69) | 0.08<br>(0.96) | 0.79<br>(0.87) | -0.41<br>(0.81) |
| **Maternal behaviors** | | | | | | |
| Breastfeeding at discharge (%) | 1.84*<br>(0.88) | 2.66**<br>(0.73) | 0.40<br>(0.87) | 1.54<br>(0.82) | 2.25**<br>(0.74) | 0.53<br>(0.91) |
| **Maternal health** | | | | | | |
| Had lower than recommended weight gain during pregnancy (%) | -0.73<br>(0.70) | -1.17*<br>(0.59) | -2.28**<br>(0.68) | -3.85**<br>(0.75) | -3.00**<br>(0.71) | -1.98*<br>(0.84) |
| Had higher than recommended weight gain during pregnancy (%) | 2.31**<br>(0.89) | 2.31**<br>(0.74) | 1.08<br>(0.88) | 3.42**<br>(0.87) | 2.34**<br>(0.81) | -0.13<br>(0.96) |
| **Medicaid costs** | | | | | | |
| Medicaid costs for newborn and mother from birth through 60 days postpartum ($)[a,b] | -635*<br>(305) | -632**<br>(237) | -657**<br>(237) | 18<br>(171) | 34<br>(122) | -20<br>(124) |
| Medicaid costs for newborn and mother from the prenatal period through 60 days postpartum ($)[a,b] | -675<br>(349) | -809**<br>(279) | -964**<br>(309) | 599**<br>(195) | 330*<br>(138) | -42<br>(137) |

Table III.7. (*continued*)

Sources: WM-II database for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid-covered births in Missouri from April 2010 to March 2011 and in Oklahoma from February 2010 to January 2011 linked with a Vital Records birth certificate. Some observations were dropped, on a variable-by-variable basis, because of missing data. Refer to Appendix E, Table E.4 for sample sizes, by outcome and group.

Table III.3 defines outcomes. The low birthweight and very low birthweight outcome measures are binary indicators of birthweight fewer than 2,500 g and fewer than 1,500 g, respectively. SGA infants had birthweights below the 10th percentile for gestational age based on race or ethnicity- and gender-specific reference standards. Neonatal infant mortality includes infant deaths occurring fewer than 28 days after birth. Lower than [higher than] recommended weight gain during pregnancy are weight gains 10 percent or more below [above] the IOM recommendations.

The tables present the differences in the outcomes between each group of WIC participants (that is, WIC participants who began participation in the first, second, or third trimesters, separately for each State) and a corresponding matched comparison group of nonparticipants, so that the matched comparison group for each group of participants was constructed with IPW, as described in the text. The propensity score model included gestational age and the full set of covariates shown in Table III.4. Robustness checks in Appendix F present the results with alternative samples and specifications of the propensity score model.

Robust standard errors are in parentheses. Asterisks indicate statistically significant differences between WIC participants and nonparticipants at the $p < .01$ (**) and $p < .05$ (*) levels, where tests for statistical significance did *not* account for multiple comparisons.

[a] The analysis of Medicaid costs in Missouri includes only fee-for-service recipients. About 64 percent of Medicaid recipients in Missouri receive care through Medicaid managed care plans. Medicaid managed care claims in Missouri do not include information about actual costs of services.

[b] The analysis of Medicaid costs excludes Native Americans. Oklahoma Medicaid did not provide cost data for Native Americans, because many of them receive care through the IHS, whose providers do not necessarily report all services and costs to Oklahoma Medicaid.

IHS = Indian Health Service; IOM = Institute of Medicine; IPW = inverse probability weighting; SGA = small-for-gestational-age; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

### 2. Estimates by length of WIC participation

Associations between WIC participation and the primary outcomes were estimated for subgroups of WIC participants defined by intensity of participation (high, medium, and low). These intensity measures were based on the share of months during pregnancy where at least one WIC food instrument was redeemed (Table III.1). Results, reported in Appendix E, Table E.15, largely mirror those reported in the previous section by trimester of WIC enrollment because women with high WIC participation tended to be those who enrolled in their first trimester. However, the two measures of WIC participation are not exactly the same since women have different pregnancy lengths and some women drop out of WIC or do not participate every month.

### 3. Subgroup analyses

Subgroup analyses were conducted to explore associations between WIC participation and the primary outcomes among subgroups defined by mother's age and household income.

#### a. Age of mother

For the most part, findings reported for the primary outcomes were consistent across age subgroups (Appendix E, Table E.16). Consistent with the findings in Section C.1, there were no statistically significant differences in either State between WIC participants and nonparticipants for the four primary birth outcome measures for the subgroup of mothers older than 17 or the subgroup 17 or younger at the time their babies were born (older and younger mothers, respectively). For the maternal behavior, maternal health, and Medicaid cost measures, the point estimates with the subgroup of younger mothers were typically in the same direction as the results for older women, but the associations between WIC and the outcomes did not always have the same level of precision. For example, prenatal WIC participants in both subgroups in both States breastfed their infants at discharge at higher rates than nonparticipants, but these differences were only statistically significant for younger mothers in Missouri and older mothers in Oklahoma. The failure to generally find statistically significant differences with the younger mothers is unsurprising given the small sample sizes. (Younger mothers represent 5 percent of women in Missouri and 6 percent of women in Oklahoma.) However, there were three exceptions in which the estimate for younger mothers was estimated imprecisely but the point estimate for younger mothers was statistically significant (breastfeeding in Missouri, higher than recommended weight gain in Missouri, and Medicaid costs from the prenatal period through 60 days postpartum in Oklahoma).

#### b. Household income

Findings for the primary outcomes differed some across income subgroups. In Missouri, the findings for WIC participants with household incomes below 100 percent of the FPL—over 95 percent of the sample—largely matched the results presented above for all WIC participants (Appendix E, Table E.MO.17). The results for the households with higher incomes were all imprecisely estimated (none were statistically significant). In Oklahoma, the findings for WIC participants with household incomes below 100 percent of the FPL—here 96 percent of the sample—also largely matched the results presented for all WIC participants. There were two outcomes where the estimates were in the same direction for higher and lower income households, but only the difference for the lower income households (the larger subgroup, with over 95 percent of the sample) was statistically significant. (The two outcomes were lower than recommended weight gain and Medicaid costs from the prenatal period through 60 days postpartum.)

Estimates were also calculated using four quantiles of household income. Note that people in quantiles 1, 2, and 3 all had incomes below 100 percent of the FPL, as did at least half the observations in quantile 4. These results reveal some heterogeneity in the associations between WIC and the outcomes among the lowest-income women, though these results should be used with caution, given the more exploratory nature of these findings (controls for multiple comparisons were not included).

## E. Checks on the robustness and external validity of the main analyses

Multiple robustness checks were conducted to confirm the accuracy of the main results and explore implications of the data limitations described in Chapter II on the generalizability of results. The results of key analyses, presented in Appendix F, can be broadly characterized as demonstrating robustness across plausible alternative methodologies, including when using alternative sets of matching variables in the IPW routine, alternative definitions of WIC participation, alternative sample inclusion or exclusion criteria, and alternative model specifications. For example, across most robustness checks, WIC participants have Medicaid costs (from the prenatal period through 60 days postpartum) considerably lower than those of nonparticipants in Missouri and roughly $400 higher than those of the nonparticipants in Oklahoma, which is consistent with the primary estimates. Estimates for outcomes measured in birth certificate data were also generally similar when missing data were imputed.

Differences in costs between WIC participants and nonparticipants were calculated across the distribution of Medicaid costs from birth through 60 days postpartum. The associations between WIC participation and the distribution of Medicaid costs differed between Missouri and Oklahoma, confirming the main finding and providing additional insights. For both measures of Medicaid costs, results for Missouri indicated that differences in Medicaid costs for WIC participants and nonparticipants were concentrated among the mother-infant dyads with high Medicaid costs. This is consistent with the main results, which found that much of the difference between Medicaid costs of WIC participants and nonparticipants in Missouri accrued from reductions in inpatient costs. In Oklahoma, Medicaid costs from birth through 60 days postpartum were higher for WIC participants than for the matched nonparticipants from the 25th to the 85th percentiles, but prenatal WIC participation might have been associated with some differences in Medicaid costs in one or both tails of the distribution. After adding prenatal costs to the Medicaid cost measure, Medicaid costs in Oklahoma were higher for WIC participants—that is, the estimate was greater than zero—for *every* quantile of the distribution, and these differences were statistically significant across most of the distribution. Appendix F discusses these results in more detail.

Three sets of robustness checks addressed the limitation of the Missouri data, discussed in Chapter II, that the Medicaid claims data do not include costs for beneficiaries enrolled in Medicaid managed care. First, as shown in Appendix F, there were some differences between the characteristics of fee-for-service beneficiaries (for whom Medicaid costs are available) and managed care beneficiaries (for whom costs are unavailable). Differences were expected given that managed care and fee-for-service beneficiaries are located in different counties. For example, compared with the fee-for-service group, managed care beneficiaries are relatively less often Hispanic or white, had more education, less often from rural areas, more often have household incomes below the poverty level, and participate in SNAP and TANF at higher rates. This indicates that associations between WIC and the study outcomes might not necessarily be the same for the two groups. Second, subgroup analysis with the (primary) outcomes from the birth certificate and the exploratory health care utilization measures were conducted separately for the fee-for-service and managed care Medicaid beneficiaries. A number of differences were identified. In particular, the association between WIC participation and higher breastfeeding rates and maternal weight gain, discussed previously, is primarily the result of differences in breastfeeding rates and weight gain between WIC participants and nonparticipants in managed care (there were no statistically significant differences in breastfeeding rates and weight gain between WIC participants and nonparticipants in fee-for-service). There were no significant associations between WIC participation and birth outcomes in either subgroup.

Second, subgroup analyses with health care utilization outcomes were conducted separately for mother–infant dyads in Missouri in Medicaid managed care and fee-for-service Medicaid to explore the degree to which the association between WIC and health care utilization for mother–infant dyads enrolled in Medicaid managed care (for whom data on Medicaid costs are unavailable) might be similar with the associations between WIC and health care utilization for the dyads enrolled in fee-for-service Medicaid. If the associations between WIC and health care utilization are similar for both groups, then one might infer that the (unobserved) association between WIC and health care costs for the managed care enrollees might be similar to the (observed) association between WIC and health care costs for dyads in fee-for-service Medicaid. Some associations between WIC participation and the health care utilization measures were different for fee-for-service beneficiaries and managed care beneficiaries. For example, WIC participation appears to be associated with lower infant hospital utilization for fee-for-service beneficiaries, and WIC participation appears to be associated with increases in mothers' outpatient utilization for managed care beneficiaries. Among fee-for-service beneficiaries, the NICU admission rate for infants of prenatal WIC participants was 2.0 percentage points lower than for the matched comparison group, but there were no differences in NICU admissions between participants and nonparticipants in the managed care subgroup. These results indicate the negative association between WIC participation and Medicaid costs among fee-for-service beneficiaries probably does not wholly translate to the managed care population.

Third, a sophisticated imputation exercise was conducted to estimate the association between WIC participation and Medicaid costs for the managed care population. If the managed care beneficiaries had instead been in fee-for-service, the patterns of health care utilization (and other variables included in the model) observed in the data indicate that the managed care WIC participants would have had Medicaid costs from the delivery through 60 days postpartum that were \$335 lower than the matched managed care nonparticipants (\$5,003 versus \$5,338, SE = \$164, $p = 0.043$—about 30 percent smaller than the comparable estimate for the fee-for-service beneficiaries (\$589). Pooling across the managed care and fee-for-service beneficiaries, the average association between WIC participation and Medicaid costs from the delivery through 60 days postpartum is most likely in the neighborhood of \$433 (\$5,677 versus \$6,110, SE = \$130, $p = 0.001$).

In addition, robustness checks addressed the two limitations of the Oklahoma data discussed in Chapter II. First, Appendix F shows the results to be unchanged if the analysis includes the mother–infant dyads that might have participated in WIC through a Cherokee or Potawatomi clinic (these observations are excluded from the main analyses because of missing data on WIC participation from the Cherokee or Potawatomi ITOs). Second, the characteristics of Native Americans (for whom Medicaid claims data are unavailable) were compared with those of non-Native Americans (when Medicaid claims data are available) and subgroup analyses were performed for the birth outcomes measured on the birth certificates (for whom data are available for both Native Americans and non-Native Americans). Results for the birth outcomes were similar for both Native Americans and non-Native Americans, but there appears to be heterogeneity between these two groups in the associations between WIC and breastfeeding and weight gain during pregnancy.

Appendix F also describes descriptive analyses that were conducted to understand the role of colocating and integrating WIC and Medicaid services at county health clinics, which is common in Oklahoma (but less so in Missouri) and potentially helps connect women to prenatal care services. This difference between the States may at least partially explain why outpatient Medicaid costs for mothers in Oklahoma were higher for WIC participants than for the matched comparison group of nonparticipants.

Finally, the study team used subclassification on the propensity score to check for heterogeneity in the associations between WIC participation and study outcomes between women who were statistically more or less likely to participate in WIC during their pregnancies. This analysis partitioned the sample into 10 subclasses based on each dyad's estimated propensity scores. The mean outcomes were compared within each subclass.[42] Associations between WIC participation and breastfeeding at discharge varied across subclasses in Missouri, but with no clear pattern. For all other outcomes in both States, hypothesis tests failed to reject the null hypothesis that associations between WIC participation and the primary outcome measures were the same across all 10 subclasses (Appendix E, Table E.18).

## F. Replication of WM-I methods

The main findings from WM-II reported in this chapter are not consistent with findings from WM-I. WM-I found that prenatal WIC participation was associated with savings in Medicaid costs (from birth through 60 days postpartum) in all five study States (Devaney et al. 1990). In contrast, WM-II found that prenatal WIC participation was associated with lower Medicaid costs in one State but not the other. In addition, WM-I found a favorable association between prenatal WIC participation and birth outcomes, but WM-II did not find such associations in either state.

There are many reasons that associations between WIC participation and the study outcomes might differ between WM-II and the WM-I study conducted more than 20 years ago. Naturally, readers may be interested in comparing the results from WM-II with the original WM-I study, even if such comparisons are inexact and the studies were conducted in different States. Because of (1) differences in the research methods used, such as the matching on gestational-age to

[42] See Imbens and Rubin (2015, Ch. 17) for details on this type of analysis. Two birth outcomes—very low birthweight and neonatal mortality—could not be included in these analyses as these outcomes are relatively rare.

account for gestational-age bias, and (2) changes in the WIC population over the intervening decades, results from the two studies are not directly comparable. Additional analyses, reported in in Appendix F, explore the degree to which these differences explain differences in results between WM-I and WM-II.

Seven different model specifications were implemented to isolate the relative influence of analytic differences between WM-I and WM-II on the different conclusions reached by the two studies. These specifications focus on differences between the methods used in WM-I and WM-II in terms of (1) methods used to control for selection bias, (2) controlling for gestational age, (3) availability of control variables, (4) use of prenatal care as a control variable, (5) inclusion or exclusion of multiple births, and (6) adjusting for multiple comparisons.

Collectively, the results in Appendix F indicate that the most important difference between WM-I and WM-II methods is controlling for gestational age in WM-II. The matched comparison group constructed for WM-II ensured that nonparticipating mother-infant dyads had pregnancies with the same gestational lengths observed among WIC participants. This removes biases caused by the effect of gestational age on WIC participation, but also effectively eliminates the potential to measure impacts of WIC on birth outcomes that occur through the channel of increased gestational lengths. The most widely cited, best-known results from WM-I are based on models that did not address gestational-age bias. Controlling for gestational age reduced the estimates of the association between prenatal WIC participation and Medicaid costs and mean birthweight (although the amount that estimates were reduced varied by outcome and State). Other studies, such as Joyce et al. (2008), have also found that associations between WIC participation and birth outcomes were smaller after addressing concerns about gestational-age bias.[43]

In addition, because of the 2003 revision to birth certificates, WM-II included a number of variables that were not available to WM-I researchers, including a number of important pre-pregnancy risk factors. It appears selection bias was addressed more credibly in WM-II due to the additional matching variables, and this often led to smaller associations between prenatal WIC participation and the outcomes.

The WIC and Medicaid programs have expanded since WM-I was conducted, and both programs now serve women and infants at higher income levels than at the time of WM-I.[44] In Appendix F, a direct assessment of the influence of WIC and Medicaid expansions on study findings was made through subgroup analyses with the sample of households with incomes less than or equal to 30, 33, 50, 88, or 100 percent of the FPL. While the disparity in findings for WM-I and WM-II could be partially explained by changes in the WIC and Medicaid populations in the intervening period, these subgroup analyses do not indicate that there are large differences

[43] See Colman et al. (2012) for a recent review of the literature.

[44] Another related issue is that there are differences between WM-I and WM-II in the racial or ethnic composition of the WIC population (for example, the proportion of pregnant women who are black or Hispanic) and the associations between WIC participation and study outcomes might be heterogeneous across women with different races or ethnicities. It was not possible to assess the potential impact of these differences on WM-II findings because WM-I did not report results for race and ethnicity subgroups. A final related issue is that the main analytic approach in WM-II could not be used to estimate the association between WIC participation and preterm delivery—one of the main outcomes in WM-I.

in the associations between WIC participation and study outcomes between women with different levels of income. It is more likely that discrepancies between WM-I and WM-II findings are related to the methodological differences described above.

## G. Summary and conclusions

The WM-II prenatal analysis was modeled on the WM-I study, which found (more than 20 years ago) that prenatal WIC participation "improved birth outcomes [birthweight and gestational age] and generated savings in Medicaid costs for mothers and newborns [from birth through 60 days postpartum]" (Devaney et al. 1992). Based on the results of WM-l and more recent studies (reviewed by Colman et al. 2012), the study team hypothesized that prenatal WIC participation would improve maternal nutrition, maternal behaviors, and birth outcomes, and be associated with decreased Medicaid costs from birth though 60 days postpartum and increased Medicaid costs in the prenatal period.

**Breastfeeding.** In both Missouri and Oklahoma, prenatal WIC participation was associated with increased breastfeeding at the time of hospital discharge. This association was in the hypothesized direction and supplementary analysis found, plausibly, that the pattern was stronger for women who began participating in WIC earlier in their pregnancies. However, the finding differs from most prior research—only 1 of 13 studies reviewed by Colman et al. (2012) found a positive association between prenatal WIC participation and breastfeeding initiation. It is worth noting that the time frame for WM-II covers a period after the revised WIC food packages, including an enhanced package for breastfeeding women, were implemented. The revised WIC food packages were not a factor in any of the studies reviewed in Colman et al. (2012). Consequently, WM-II may provide evidence that the changes to the WIC food packages and related efforts by WIC agencies to promote and support breastfeeding could be having their intended effect. It is also possible that the differences in findings between WM-II and prior research are attributable to differences in data sources and/or analysis methods, particularly the definitions used to identify WIC participants and women who initiated breastfeeding and the carefully matched sample of nonparticipants.

**Maternal weight gain.** In both Missouri and Oklahoma, prenatal WIC participation was associated with increased maternal weight gain during pregnancy. Specifically, WIC participants in both States were more likely than nonparticipants to have gained more than the recommended amount of weight and, in Oklahoma, WIC participants were less likely than nonparticipants to have gained less than the recommended amount of weight. This finding is consistent with findings from two prior studies that examined the association between WIC participation and weight gain during pregnancy (Colman et al. 2012). Because more than half of all WIC participants in both Missouri and Oklahoma were overweight or obese, the association between WIC participation and higher-than-recommended weight gain can be viewed as a negative finding and might require additional attention from WIC policymakers. The findings that WIC participants in Oklahoma were less likely than nonparticipants to have lower-than-recommended weight gain is likely a positive finding—an indication that more WIC participants than nonparticipants are achieving the weight gain recommended by the IOM.

**Birth outcomes.** There was no associations in either Missouri or Oklahoma between prenatal WIC participation and the birth outcomes examined in this analysis (low and very low birthweight, fetal growth, and neonatal infant mortality). The results for birth outcomes (and Medicaid costs, discussed below) are not consistent with the main findings from WM-I. Exploratory analyses that isolated the potential influence of methodological differences indicate that the most important difference between WM-I and WM-II is the use of analytic methods that might have more credibly addressed gestational-age bias and, to a lesser extent, selection bias. This analytic approach removes biases caused by the effect of gestational age on WIC participation, but also effectively eliminates the potential to measure impacts of WIC on birth outcomes that occur through the channel of increased gestational lengths. Associations between WIC participation and the study outcomes in WM-II would have been considerably larger—more similar to WM-I—if the WM-II specifications had not removed gestational-age bias. The results from WM-II are, however, more in line with other recent studies that have found weak associations between prenatal WIC participation and fetal growth when adjusting for gestational-age bias (Colman et al. 2012). However, secondary analyses using a hazard model revealed some differences between WIC participants and matched nonparticipants in the probability of delivering in certain stages of pregnancy, which implies the method of removing gestational-age bias may have been conservative and underestimated a potential association between WIC participation and other birth outcomes. More research is needed to assess the degree to which a causal association between WIC participation and gestational lengths might have attenuated the estimated associations between prenatal WIC participation and other birth outcomes, but there is reason to believe that these results could be less biased than results from an analysis that did not address gestational-age bias. (Unadjusted analyses would almost certainly have overestimated the association between prenatal WIC participation and birth outcomes and, by extension, Medicaid costs.)

**Medicaid costs.** Among fee-for-service Medicaid beneficiaries in Missouri, prenatal WIC participation was associated with lower Medicaid costs (for birth through 60 days postpartum as well as the prenatal period through 60 days postpartum). In Oklahoma, Medicaid costs from birth through 60 days postpartum were similar for prenatal WIC participants and matched nonparticipants. The association between prenatal WIC participation and Medicaid costs among fee-for-service beneficiaries in Missouri is consistent with findings from WM-I and the study team's hypotheses, but the association in Oklahoma is not consistent.

The study team conducted a variety of exploratory analyses to understand why associations between WIC participation and Medicaid costs might differ across the two study States and why Medicaid costs might be lower for WIC participants than for the matched comparison group in Missouri in the absence of significant associations between prenatal WIC participation and birth outcomes. (The lower Medicaid costs observed among WIC participants in WM-I were hypothesized to be driven by improved birth outcomes, but WM-II did not find a significant association between WIC participation and birth outcomes, after addressing gestational-age bias.) These exploratory analyses showed that differences in the findings across States were driven by differences in the association between WIC participation and inpatient costs from birth through 60 days postpartum.[45] In Oklahoma, Medicaid costs for inpatient (hospital) services were similar for WIC participants and the matched comparison group of nonparticipants—a

[45] The differences between the States are not due to non-inpatient costs from birth through 60 days postpartum; for those outcomes, results for Missouri and Oklahoma were similar.

finding that contrasts with findings from Missouri but is consistent with the lack of association between prenatal WIC participation and birth outcomes. In Missouri, on the other hand, WIC mothers and their infants used fewer inpatient (hospital) services from birth though 60 days postpartum than the matched comparison group. This result is robust across a number of specification checks and robustness tests. Most notably, the infants of WIC participants in Missouri were admitted to the NICU at lower rates, although the lower NICU admission rates cannot be explained by differences in birth outcomes, differences in the hospitals where WIC participants give birth, regions of the State where WIC participants live, or the admission of infants with particular diagnosis codes into the NICU. Thus, an explanation remains elusive of how, exactly, WIC participation might lower infant NICU costs in Missouri through a channel other than birth outcomes. One interesting point of comparison is that hospitals in Oklahoma are paid using a diagnosis-related group (DRG) classification system, and there was no association between WIC participation and hospital utilization and costs. In Missouri, on the other hand, hospitals were paid on a per-diem basis, and there was an association between WIC participation and hospital inpatient utilization and costs.[46] Another point of comparison is that the case management programs for pregnant women differ between the two States.[47]

For the measure of Medicaid costs that includes costs from the prenatal period, differences also arise between Missouri and Oklahoma from mothers' non-inpatient costs during pregnancy.[48] Overall, results from secondary analyses and exploratory analyses support the hypothesis that the WIC program in both States connects women to prenatal care and other types of health care services during the pregnancy.[49] For example, analysis with secondary outcome measures revealed strong associations between WIC participation and increased rates of receiving adequate prenatal care and the number of Medicaid-paid office visits in both States (although the magnitude of these associations varied somewhat between the States). In Oklahoma, these associations contributed to a large difference in prenatal Medicaid costs between WIC participants and nonparticipants, but in Missouri the prenatal Medicaid costs were similar for WIC participants and nonparticipants. One potential explanation is that the prenatal WIC participants had more ER visits than nonparticipants in Oklahoma, while in Missouri, they

[46] A DRG payment system is designed to pay inpatient facilities a fixed fee for patients with a given condition and treatment strategy. Patient stays are assigned to Medicare DRGs, which group patients with similar clinical problems that are expected to require similar amounts of hospital resources (Medicare Payment Advisory Commission 2015). The payment a hospital receives does not generally vary across patients with the same DRG code, even if some of those patients have, for example, longer lengths of stay. Thus, under a DRG payment system, it would be possible for WIC participation to be associated with inpatient utilization measures (for example, length of stay) but not inpatient Medicaid costs. In Missouri's fee-for-service program, delivery claims for hospital services were paid on a per-diem rate, and physicians bill for professional services separately from the hospital (perhaps along with charges for maternity services as part of a global fee).

[47] See Appendix E, Table E.19, for a brief description of Medicaid case management programs in the two States.

[48] In both States, there were no differences in Medicaid costs for inpatient claims between WIC participants and matched nonparticipants in the prenatal period.

[49] As noted below, an alternate explanation—that pregnant women who are more connected to the health care system in general or require more non-inpatient care are also more likely to enroll in WIC—cannot be ruled out.

did not.[50] Interviews with representatives from Oklahoma's WIC and Medicaid agencies suggest another potential explanation for the association between prenatal WIC participation and outpatient Medicaid costs. Unlike Missouri, many local WIC clinics in Oklahoma (the places where women sign up for and receive WIC benefits) are at county health clinics where WIC and Medicaid services are highly integrated. This integration potentially has a beneficial effect in connecting women to prenatal care services, and might at least partially explain why outpatient Medicaid costs for mothers in Oklahoma were higher for the WIC participants and the matched comparison group of nonparticipants (in comparison to Missouri).[51] However, an alternate explanation—that pregnant women who are more connected to the health care system in general are also more likely to enroll in WIC—cannot be ruled out.

Supplemental analyses were conducted to examine the associations between prenatal WIC participation and the primary outcomes among selected subgroups of women—by age and household income. On the whole, there was only limited evidence that the association between WIC participation and the primary outcomes varied across groups. For some outcomes (but not others), associations between prenatal WIC participation were larger for women who began participating in WIC early in their pregnancies. Multiple robustness checks were conducted, and the key results can be broadly characterized as demonstrating robustness across plausible alternative methodologies.

Some caution is warranted in interpreting these results. Selection bias remains a concern. As shown in Appendix D, IPW resulted in a well-matched comparison group—that is, IPW substantially reduced or eliminated any observed differences between WIC participants and nonparticipants on a number of important pre-pregnancy risk factors. This reduces the likelihood that underlying differences are responsible for estimated associations between WIC participation and the outcomes, though absent a randomized controlled trial, the potential for selection bias cannot be completely ruled out. Even after balancing the WIC participants and the matched comparison groups in terms of observable characteristics, it is possible that unobserved differences remain between the two groups. This retrospective observational study does not necessarily demonstrate a causal association between prenatal WIC participation and these outcomes. For example, differences in breastfeeding at discharge may reflect unobserved differences between women's characteristics, behaviors, or environments rather than the effects of WIC.

Another concern is that infants of prenatal WIC participants are enrolled in WIC at higher rates than the infants of nonparticipants. Given that some WM-II outcomes were measured through the first 60 days after birth, it is likely the analysis did not actually disentangle the associations between those outcomes and *infant* WIC participation (in the first 60 days) from the associations with mother's *prenatal* WIC participation—that is, the results in this chapter are

[50] Unnecessary emergency room (ER) visits might indicate poor access to appropriate care from primary care providers or other providers, so many policymakers prefer to see lower rates of ER use (for example, see Burwell 2016). However, some studies have found interventions to increase both physician office visits and ER use, suggesting the two types of services are complimentary (for example, see Finkelstein et al. 2016).

[51] For more discussion on this issue, see Section I in Appendix F.

likely picking up effects of WIC participation in the infant's first 60 days. Without data on infants' WIC participation in the first 60 days, the study cannot assess the magnitude of these effects.

It is also worth noting that the results are estimates of the associations between prenatal WIC participation and outcomes through the first 60 days after the delivery, as opposed to the entire time mothers and infants might be enrolled in the Medicaid program.[52] The WM-I study included an addendum that estimated Medicaid costs through one year after birth (Devaney et al. 1991b), and found that associations between WIC participation and Medicaid cost savings were larger when the costs from days 61 through one year were included (particularly in Minnesota). In WM-II, prenatal WIC participation was associated with higher utilization of some health care services, including well-child office visits. One could hypothesize that increased Medicaid expenditures and health care utilization early in infants' lives for preventive newborn health care may still lead to reduced Medicaid costs in the long run if the underutilization of these services by non-WIC participants leads to more health problems later.

In the end, it was feasible to link data from State WIC, Medicaid, and Vital Records in Oklahoma and Missouri to re-examine research findings reported in the WM-I study 20 years ago, but results of the new study need to be interpreted with caution. As discussed in Chapter II, there were several significant study sample restrictions related to data limitations—most notably with analyses of outcomes measured in Medicaid data. Fee-for-service data to measure Medicaid costs were not available for all Medicaid beneficiaries in either of the study States. In Missouri, only about one-third of the sample members were covered by fee-for-service. Although all Medicaid beneficiaries in Oklahoma were covered by fee-for-service arrangements, Oklahoma did not provide Medicaid claims data for Native Americans.[53] Sensitivity analyses in Missouri revealed differences in characteristics between fee-for-service and managed care Medicaid beneficiaries, and some differences in the associations between WIC participation and health care utilization. For these reasons, the results presented in this chapter do not generalize to the entire Medicaid population in Missouri or Oklahoma, or generalize to other States.

Despite recognized data limitations, the WM-II prenatal analysis included important methodological advances, relative to WM-I and can inform future research on the potential impacts of prenatal WIC participation. These advances include use of IPW to control for measured differences between WIC participants and nonparticipants; an expanded set of control variables; enhanced methods to remove gestational-age bias; an expanded set of outcomes, including maternal weight gain and breastfeeding at discharge; and a number of subgroup and sensitivity analyses. Future work examining associations between WIC participation and birth

[52] Federal Medicaid policy covers pregnant women with perinatal care for 60 days postpartum. However, some women may qualify for Medicaid and extend their Medicaid enrollment beyond the 60th day. Medicaid automatically coves newborns for the first 365 days following a Medicaid-covered delivery.

[53] These analyses of birth outcomes, maternal behaviors, and maternal health measures (from birth and death certificated data) included the entire sample in Missouri and almost the entire sample in Oklahoma. Native Americans are a small share of the total population in Oklahoma. Several of the exploratory analyses in Appendix F provide new findings about the association between WIC participation and Medicaid outcomes for Missouri's managed care population—an important advance for the field.

outcomes could continue to develop methods for addressing gestational-age bias in ways that allow the examination of all birth outcomes potentially impacted by WIC.

At a minimum, the WM-II prenatal analyses demonstrate the need for continued research on pregnant women and infants who participate in the ever-changing WIC and Medicaid programs. The prenatal analysis demonstrated some heterogeneity across the two study States and across subgroups within States in the associations between prenatal WIC participation and outcomes of interest. Future work using data from additional States and potentially new research methods could pursue a more complete understanding of the nature of this heterogeneity and the reasons WIC participation might or might not be associated with particular outcomes in particular States or with particular types of WIC participants.

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# IV. FINDINGS FROM THE CHILDREN'S ANALYSIS

The WIC program serves children ages 1 to 4 who are at nutritional risk. For children, who account for more than half of all WIC participants (Thorn et al. 2015), the program aims to prevent health problems and protect health status by providing nutritious supplementary foods, nutrition education, and referrals to health and social services during a critical period of growth and development. WIC staff assess participants' access to health care services and advise parents or caregivers about recommended health care practices for young children, including well-child visits; immunizations; and EPSDT services.

This chapter presents findings from the children's analysis, which was modeled on the Buescher study and implemented using the linked database and analytic sample described in Chapter II. In contrast to the prenatal analysis where, based on WM-I, WIC participation was expected to be associated with lower Medicaid costs (mainly because of improved birth outcomes), child WIC participation was expected to be associated with increased health care utilization, particularly the use of preventive services, and *higher* Medicaid costs (Buescher et al 2003; Lee et al, 2004a and 2004b). In the long run, increased use of health care services is expected to improve children's overall health status.

Findings should be interpreted with caution because of the data limitations described in Chapter II. Although the results of the analyses are expected to have high internal validity, the data limitations mean that results are not necessarily generalizable to the entire Medicaid populations in Missouri or Oklahoma, or to Medicaid populations in other States. The study team conducted a number of sensitivity analyses and robustness checks to shed light on the implications of the sample limitations. Findings from these supplementary analyses are summarized in this chapter and in appendices referenced throughout the chapter. Appendices are included in a separate volume.

## A. Analytic approach

The children's analysis examined the association between WIC participation during childhood and health care utilization, the diagnosis and treatment of common childhood illnesses, and Medicaid costs. The analysis focused on children ages 1 to 4 who were continuously enrolled in Medicaid during calendar year 2010, and compared outcomes of children who participated in WIC at any time between their first birthday and the end of calendar year 2010 with outcomes of a matched comparison group of children who never participated in WIC during the same time frame.

### 1. Defining WIC participation

The study team used administrative records from the WIC program to identify children who participated in WIC. As in the prenatal analysis, the team based its definition of WIC participation on the redemption of WIC food instruments rather than WIC certification. WIC food instrument data were obtained for 2006 to 2010, so that a complete record of WIC participation after the first birthday was available for all children in the sample. The primary measure of WIC participation in this analysis classified a child as a WIC participant if a food instrument issued by WIC was redeemed between their first birthday and December 2010. Children were classified as nonparticipants if they enrolled in WIC as children but did not redeem any food instruments.[54] The measure of WIC participation used in this analysis differs from the regulatory definition, which includes all children who are issued a food instrument, regardless of redemption. The advantage to using instrument redemption to identify WIC participants is that it excludes children who enrolled in WIC but never actually redeemed the food instruments issued to them.

Table IV.1 defines the primary measure of WIC participation as "any WIC." In Missouri, 71 to 78 percent of children in each of the age cohorts participated in WIC (redeemed at least one food instrument). The pattern was similar in Oklahoma; the percentage of children in each age cohort who participated in WIC ranged from 70 to 78 percent. Participation rates tended to be slightly higher for the older cohorts (Chapter II, Table II.6). This reflects the fact that the measure of participation considered every month from a child's first birthday through December 2010—older children had more time to participate in WIC.

### Table IV.1. Measures of child WIC participation

| | Measure |
|---|---|
| Any WIC participation (binary measure) | = 1 if at least one WIC food instrument was redeemed after first birthday and before end of calendar year 2010; 0 otherwise |
| Length of WIC participation (binary measures) | Low, medium, and high levels of participation based on the percentage of months after a child's first birthday through the end of 2010 in which at least one food instrument was redeemed<br><br>= 1 if food instruments were redeemed for 1–33 percent, 34–67 percent, and more than 67 percent of months, respectively; 0 otherwise |

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

The study team also created a categorical measure that categorized WIC participants based on length of WIC participation. This measure reflects the percentage of months after a child's first birthday through the end of December 2010 in which at least one WIC food instrument was redeemed. WIC participants were classified into groups having low (1–33 percent of months), medium (34–67 percent of months), or high (more than 67 percent of months) lengths of participation.[55] Table IV.2 shows the percentages of children in each category by State and age cohort. Children tended to participate in WIC at higher rates when they were younger and drop out of the program over time (Appendix G, Table G.1). As a result, more children from the younger age cohorts are classified in the high WIC participation category. For example, the table shows that over 50 percent of WIC participants in the 1-year-old age cohort were categorized as having high WIC participation, compared to less than one-third of WIC participants in the 4-year-old age cohort.

[54] Data on the prenatal WIC participation of the children's mothers, or the children's participation in WIC as infants were not collected. These data were not needed to replicate the Buescher study and collection of these data would have imposed a significant burden on the State WIC agencies

[55] Some of the oldest children in the 4-year old cohort ceased to be eligible in the last few months of 2010 (up to 5 months for a child born in July 2005). However, this feature of the data is unlikely to have had a substantial impact on the proportion of children classified as having high, medium, or low WIC participation because 5 months represents no more than 8 percent of the 60 months from a child's first birthday through the end of December 2010 (the denominator used in the calculation of length of participation).

**Table IV.2. Number and percentage of children with any WIC participation and different doses of WIC participation, by age cohort**

| WIC participation | Cohort of 1-year-olds N | Cohort of 1-year-olds % | Cohort of 2-year-olds N | Cohort of 2-year-olds % | Cohort of 3-year-olds N | Cohort of 3-year-olds % | Cohort of 4-year-olds N | Cohort of 4-year-olds % |
|---|---|---|---|---|---|---|---|---|
| **Missouri** | | | | | | | | |
| Any WIC | 21,295 | 100.0 | 21,833 | 100.0 | 21,243 | 100.0 | 19,391 | 100.0 |
| Low WIC | 4,776 | 22.4 | 6,347 | 29.1 | 7,495 | 35.3 | 7,995 | 41.2 |
| Medium WIC | 5,101 | 24.0 | 5,643 | 25.8 | 5,854 | 27.6 | 5,319 | 27.4 |
| High WIC | 11,418 | 53.6 | 9,843 | 45.1 | 7,894 | 37.2 | 6,077 | 31.3 |
| **Oklahoma** | | | | | | | | |
| Any WIC | 12,116 | 100.0 | 12,066 | 100.0 | 12,152 | 100.0 | 11,047 | 100.0 |
| Low WIC | 2,356 | 19.4 | 3,205 | 26.6 | 3,915 | 32.2 | 4,341 | 39.3 |
| Medium WIC | 2,934 | 24.2 | 3,372 | 27.9 | 3,548 | 29.2 | 3,206 | 29.0 |
| High WIC | 6,826 | 56.3 | 5,489 | 45.5 | 4,689 | 38.6 | 3,500 | 31.7 |

Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Note: Based on Medicaid beneficiaries in Missouri and Oklahoma continuously enrolled from January to December 2010 linked with a birth certificate.

WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

## 2. Outcome measures

The children's analysis examined outcomes in three domains: (1) health care utilization, (2) diagnosis and treatment of common childhood illnesses, and (3) Medicaid costs. The specific measures used in the analysis are described in the following sections and summarized in Table IV.3. The table identifies primary and secondary outcomes in each domain. As in the prenatal analysis, the study team selected a parsimonious list of primary outcomes to minimize the likelihood of finding false positives as a result of conducting a large number of statistical tests (Schochet 2009). The main analysis focused on four primary outcomes—the prevalence of well-child visits, ER visits, visits associated with common childhood illnesses, and total Medicaid costs—and the use of rigorous statistical methods. The analysis of secondary outcomes did not use the same level of statistical control, and the findings are thus more exploratory. Findings for all primary outcomes are discussed in this chapter; secondary outcomes are also discussed in this chapter, with detailed results presented in Appendix G.

## Table IV.3. Outcome measures for the children's analysis

| Construct | Measure | Definition | Primary outcome | Secondary outcome |
|---|---|---|---|---|
| | | **Domain: Health care utilization** | | |
| Any utilization of Medicaid-covered health care services | Well-child visits | Binary indicator of any well-child visits | ✓ | |
| | ER visits | Binary indicator of any ER visits | ✓ | |
| | Immunization visits | Binary indicator of any immunization visits | | ✓ |
| | Recommended EPSDT visits[a] | Binary indicator of receiving recommended EPSDT visits, based on child's age | | ✓ |
| | Hospitalizations | Binary indicator of any hospitalizations | | ✓ |
| | Dental care visits | Binary indicator of any dental care visits | | ✓ |
| Continuous measures of Medicaid-covered health care utilization | Immunization visits | Number of visits with an immunization | | ✓ |
| | Well-child visits | Number of well-child visits | | ✓ |
| | Hospitalizations | Number of hospitalizations | | ✓ |
| | Days in hospital | Number of days hospitalized | | ✓ |
| | ER visits | Number of ER visits | | ✓ |
| | Dental care visits | Number of dental care visits | | ✓ |
| | | **Domain: Diagnosis and treatment of common childhood illnesses** | | |
| Diagnosis and treatment of common childhood illnesses | Any common childhood illness | Binary indicator of any visits for any of the measured illnesses (listed below) | ✓ | |
| | Otitis media | Binary indicator of any visits for otitis media | | ✓ |
| | Upper respiratory infection | Binary indicator of any visits for upper respiratory infection | | ✓ |
| | Lower respiratory infection | Binary indicator of any visits for lower respiratory infection | | ✓ |
| | Asthma | Binary indicator of any visits for asthma | | ✓ |
| | Iron deficiency anemia | Binary indicator of any visits for iron deficiency anemia | | ✓ |
| | Gastroenteritis | Binary indicator of any visits for gastroenteritis | | ✓ |
| | Allergy | Binary indicator of any visits for allergies | | ✓ |
| | | **Domain: Medicaid costs** | | |
| Medicaid costs | Total Medicaid costs[b] | Continuous measure of costs | ✓ | |
| | Physician costs[b] | Continuous measure of costs for physician claims and other carrier claims (except for dental claims) | | ✓ |
| | Outpatient costs[b] | Continuous measure of costs (including most ER claims) | | ✓ |

| Construct | Measure | Definition | Primary outcome | Secondary outcome |
|---|---|---|---|---|
| | Prescription drug costs[b] | Continuous measure of costs for pharmacy or drug claims | | ✓ |
| | Dental costs[b] | Continuous measure of costs for dental claims | | ✓ |
| | Inpatient costs[b] | Continuous measure of costs for inpatient claims | | ✓ |
| | Other costs[b] | Continuous measure of costs for other types of claims | | ✓ |
| | ER costs | Continuous measure of costs for ER visits | | ✓ |
| | Physician costs | Continuous measure of costs for physician claims (only), excluding other types of carrier claims and dental claims | | ✓ |
| | EPSDT costs | Continuous measure of costs for EPSDT visits | | ✓ |
| | Well-child costs | Continuous measure of costs for EPSDT and other well-child visits | | ✓ |

Note: The analysis of Medicaid costs for Missouri includes only fee-for-service beneficiaries. Appendix G, Table G.2 provides additional details about the construction of the outcome measures.

[a] In addition, Appendix G includes analysis of EPSDT visits at particular ages, such as EPSDT visits for children ages 23 to 25 months.

[b] Total costs are the sum of the costs from the following mutually exclusive categories: physician and other carrier, outpatient, prescription drug, dental, inpatient, and other claims.

EPSDT = early and periodic screening, diagnostic, and treatment; ER = emergency room.

### a. Health care utilization

Analysis of the association between child WIC participation and the use of health care services primarily focused on binary measures of whether a child had at least one well-child or ER visit during calendar year 2010. Analyses of secondary measures of health care utilization included binary measures for the receipt of immunizations, recommended EPSDT or dental care visits, and hospitalizations, as well as continuous measures of health care utilization (such as the number of visits or days hospitalized).[56]

### b. Diagnosis and treatment of common childhood illnesses

The primary measure in this domain indicates whether a child had a medical visit for the diagnosis and treatment of one or more of the following common childhood illnesses: otitis media (ear infection), upper respiratory infection, lower respiratory infection, asthma, iron-deficiency anemia, gastroenteritis, and allergies. Illnesses were identified in the Medicaid claims data using *International Classification of Diseases,* 9th edition, Clinical Modification (ICD-9

[56] As noted in Chapter II, immunizations and other health care utilization measures are limited to those paid for by Medicaid that can be identified in the Medicaid claims data.

CM) diagnosis codes.[57] Analyses of secondary outcomes assessed whether a child had a medical visit for each individual illness.

### c. Medicaid costs

Analysis of Medicaid costs focused on total Medicaid costs for calendar year 2010 as the primary outcome and costs for particular types of services as secondary outcomes. The secondary outcome measures included the costs for claims in six mutually exclusive categories: (1) physician and other carrier costs, (2) outpatient costs, (3) prescription drug costs, (4) dental costs, (5) inpatient costs, and (6) other costs. The analysis also examined costs for ER visits, physician costs, EPSDT visits, and well-child visits.

## 3. Analysis methods

As noted in Chapter I, one goal of WM-II was to update and expand the Buescher study. In doing so, the study team used enhanced techniques to address the potential for selection bias. In addition, given the multiple outcomes examined, the study team included additional statistical controls in analyses that assessed the relationships between child WIC participation and the primary outcomes. The sections that follow describe the methods used to address each of these concerns and provide an overview of subgroup analyses conducted to explore associations between WIC participation and the primary outcomes among subgroups defined by mother's age and household income.

### a. Addressing selection bias

As described in detail in Chapter III, the study team used IPW to create a comparison group of nonparticipants that closely matched the WIC participants on observable characteristics. A broad array of covariates or "matching variables" was used to construct matched comparison groups for each age cohort in each State. Matching on these variables, shown in Table IV.4, ensured that the WIC participants and the matched comparison groups of nonparticipants were balanced on mothers' demographic and socioeconomic characteristics, including age, race, foreign-born status, education, marital status, smoking during pregnancy, having a previous live birth, whether there was a short interval between prior pregnancies, rural residence, and household income.[58] The WIC participant and nonparticipant groups were also balanced on the children's dates of birth, gender, rates of participation in TANF, and rates of enrollment through the Medicaid aged, blind, and/or disabled and child welfare eligibility categories. Because birth outcomes are important determinants of children's health and Medicaid costs, the study team also included birthweight, gestational age at birth, and plurality as matching variables.

IPW performed well in creating matched comparison groups for the children's analysis. Appendix D provides summary measures that demonstrate the success of the approach. However, it is still possible that children who participated in WIC differed from the matched comparison group in unobservable ways. If these other factors were also related to outcomes,

[57] For asthma, National Drug Codes on pharmacy claims were also used to identify prescriptions for inhaled corticosteroids.

[58] As noted in Chapter II, the children's analysis could include only variables that were available on the older version of the birth certificate. Thus, the resulting list of characteristics is more limited than the characteristics used in the prenatal analysis.

some selection bias could remain. For instance, there could be unobserved differences in the health conditions of the two groups, which might lead to differences in health care utilization or costs, apart from the effects of WIC.

### Table IV.4. Matching variables used in the children's analysis

| Characteristic | Variables | Data source |
|---|---|---|
| **Mother's characteristics** | | |
| Age at child's birth | 17 years or younger | BC |
| | 18 or 19 years | BC |
| | 20–34 years | BC |
| | 35 years or older | BC |
| Race/ethnicity | White non-Hispanic | BC |
| | Black non-Hispanic | BC |
| | Hispanic | BC |
| | American Indian or Alaska Native | BC |
| | Asian or Pacific Islander | BC |
| | Multiple races, other race, or unknown | BC |
| Marriage | Married | BC |
| Education | Less than high school | BC |
| | High school or GED | BC |
| | Some college credit but no degree | BC |
| | College degree[a] | BC |
| | Unknown | BC |
| Smoking during pregnancy | Any smoking during pregnancy | BC |
| Previous live births | Any previous live births | BC |
| Inter-pregnancy interval | Short inter-pregnancy interval (6–17 months) | BC |
| **Child's/household's characteristics** | | |
| Gender | Male | BC |
| Singleton or multiple birth | Multiple birth | BC |
| Gestational age at birth | Gestational age (in weeks) | BC |
| | Preterm birth (37 or fewer weeks) | BC |
| | Very preterm birth (32 or fewer weeks) | BC |
| Birthweight | Birthweight (in g) | BC |
| | Low birthweight (fewer than 2,500 g) | BC |
| | Very low birthweight (fewer than 1,500 g) | BC |
| Rural residence | Rural residence | BC |
| Household income[b] | Income 100 percent or less of the FPL | MF |
| | Income (percentage of the FPL) | MF |
| SNAP participation[c] | Child enrolled in SNAP | MF |
| TANF participation | Household enrolled in TANF | MF |
| Aged, blind, and/or disabled | Child's enrollment in Medicaid on the basis of aged, blind, and/or disabled eligibility | MF |
| Child welfare | Child welfare Medicaid enrollment category | MF |
| Medicaid managed care beneficiary (Missouri only) | One or more claims from Medicaid managed care plan, or no claims in 2010 and lived in a managed care county | MF |
| Date of birth | Quarter of birth indicator variables | BC |

Table IV.4. *(continued)*

Note: The column on the right indicates the primary data source (BC or MF). In some cases, data from the primary data source were filled in with an alternative data source in the case of missing data. For example, if the address from the BC was missing, rural residence was filled in using the address from the MF. Some variables included a dummy variable for missing data (not shown). In a few cases, so few observations were missing data that the missing data category was combined with the mode.

[a] This category includes mothers with at least a four-year college degree (bachelor's, master's, doctorate, and professional [M.D., D.D.S., D.V.M., J.D., L.L.B.] degrees). The "some college but no degree" category includes mothers with associate's degrees.

[b] Household income entered the propensity score models with categorical variables for household income $0, 1 to 100% FPL, more than 100% FPL, or missing. The second and third categorical variables were also interacted with the continuous income measure (percentage of the FPL).

[c] Data provided by a cognizant State agency in Missouri. Data on SNAP enrollment were unavailable in Oklahoma. Models in Missouri for the primary outcomes were reestimated with and without the SNAP participation variable, and findings were comparable.

[d] Missouri only.

BC = birth certificate; FPL = Federal poverty level; GED = general educational development (diploma); MF = Medicaid files; SNAP = Supplemental Nutrition Assistance Program; TANF = Temporary Assistance for Needy Families.

### b. Controlling for multiple comparisons

As discussed in Chapter III, the chances of spurious findings in any analysis increase when multiple hypotheses tests are conducted simultaneously within a given domain. To address this concern, the study team adjusted $p$-values and statistical significance reported in the tables, using the method from Hothorn et al. (2008), to account for the fact that two outcomes were examined in the health care utilization domain (see Table IV.3).

### c. Subgroup analyses

Subgroup analyses were conducted to explore associations between WIC participation and the primary outcomes among subgroups defined by mother's age and household income. The methods used for the subgroup analyses were very similar to the methods used for the main analyses. First, the study team divided each age cohort into two or more subgroups. Then the difference in the primary outcomes between WIC participants and a matched comparison group of nonparticipants was estimated separately for each subgroup for each age cohort. The matched comparison groups of nonparticipants were constructed using IPW (using the full set of matching variables listed in Table IV.4). For certain subgroups, some characteristics in the propensity score model were highly correlated or certain characteristics were extremely rare. The approach used to address this feature of the data mirrored the prenatal subgroup analyses (see Chapter III, Section A.3.d).

Findings for the subgroup analyses should be interpreted with caution. The subgroups analyses were exploratory in nature rather than testing a specific hypothesis, and they did not include the controls for multiple comparisons that were included in the main analyses. In addition, sample sizes for some subgroups were small.

## B. Characteristics of WIC participants and nonparticipants

Assessing baseline differences in the observed characteristics of WIC participants and nonparticipants provides insights about underlying unobserved factors that may affect both the decision to participate in WIC and the outcome measures. It also underscores the importance of controlling for differences in observed characteristics when estimating associations between child WIC participation and the outcome measures.

Tables IV.5 and IV.6 present descriptive statistics for Missouri and Oklahoma, respectively, on baseline (that is *prior to IPW)* demographic, socioeconomic, and health-related characteristics of WIC participants and nonparticipants. Because of the large sample sizes, many baseline differences between characteristics of WIC participants and nonparticipants were statistically significant using a Student's t-test or a chi-squared test. However, with the exception of rural residence in Missouri and race and ethnicity in Oklahoma, the differences are relatively small—less than 0.25 SDs.

In both States, mothers of WIC participants tended to be less educated than mothers of nonparticipants. Relative to mothers of nonparticipants, higher proportions of mothers of WIC participants had less than a high school education and lower proportions had at least some college. In addition, there were fewer first-time mothers in the WIC participant group, and these WIC mothers were more likely than mothers of nonparticipants to have a short inter-pregnancy interval.

For some characteristics, the pattern of findings was divergent in the two States. For example, the distribution of race and ethnicity differed between Oklahoma and Missouri. In Missouri, children who participated in WIC were more likely to be Hispanic (based on mother's race or ethnicity) and were relatively less likely to be black. In Oklahoma, on the other hand, WIC participants were more likely than nonparticipants to be white and less likely to be black. In Oklahoma, children who participated in WIC were less likely than nonparticipants to reside in rural areas, whereas, in Missouri, children who participated in WIC were relatively more likely to reside in a rural area. In both States, the differences between the WIC participant and nonparticipant groups generally exhibited similar patterns when the sample of WIC participants was limited to subgroups of children who began participating in WIC at younger or older ages (Appendix G, Table G.3).[59]

As described in Section A.3.a, the study team used IPW methods to construct matched comparison groups that greatly reduced, and often eliminated, observed differences between WIC participants and nonparticipants. Appendix D describes the IPW results in detail.

[59] WIC participants and nonparticipants were also compared using multivariate analyses that indicate whether a particular characteristic or risk factor is associated with the probability of prenatal WIC participation (the propensity score) holding all other variables constant. For many characteristics, the results from the propensity score model confirmed the results from the univariate comparisons presented in Tables IV.5 and IV.6. However, there were a few differences (Appendix G, Table G.4).

**Table IV.5. Demographic and socioeconomic characteristics and health risk factors of child WIC participants and nonparticipants in Missouri, by age cohort, before IPW**

| | Cohort of 1-year-olds | | Cohort of 2-year-olds | | Cohort of 3-year-olds | | Cohort of 4-year-olds | |
|---|---|---|---|---|---|---|---|---|
| | No WIC | WIC | No WIC | WIC | No WIC | WIC | No WIC | WIC |
| **Mother's characteristics** | | | | | | | | |
| Age at child's birth | | | | | | | | |
| ≤17 years | 4.6 | 6.8†† | 4.9 | 7.1†† | 4.3 | 6.8†† | 4.9 | 7.6†† |
| 18–19 years | 12.5 | 14.0 | 11.8 | 14.6 | 11.1 | 14.7 | 9.8 | 14.4 |
| 20–34 years | 78.2 | 73.6 | 78.2 | 73.0 | 79.1 | 73.4 | 79.7 | 73.0 |
| ≥35 years | 4.7 | 5.7 | 5.0 | 5.4 | 5.5 | 5.1 | 5.7 | 5.0 |
| Race/ethnicity | | | | | | | | |
| Non-Hispanic white | 63.1 | 64.8†† | 60.9 | 64.6†† | 60.7 | 65.2†† | 61.2 | 65.7†† |
| Non-Hispanic black | 30.0 | 24.4 | 32.4 | 25.5 | 32.8 | 25.0 | 33.1 | 24.8 |
| Hispanic | 4.3 | 8.3 | 4.3 | 7.8 | 3.9 | 7.8 | 3.8 | 7.5 |
| Non-Hispanic American Indian Alaskan Native | 0.5 | 0.6 | 0.4 | 0.7 | 0.4 | 0.6 | 0.3 | 0.5 |
| Non-Hispanic Asian Pacific Islander | 1.5 | 1.4 | 1.5 | 1.1 | 1.7 | 1.1 | 1.3 | 1.0 |
| Multiple races, other race, or unknown | 0.6 | 0.4 | 0.4 | 0.3 | 0.5 | 0.3 | 0.4 | 0.5 |
| Married | 31.3 | 32.5* | 32.5 | 32.3 | 34.7 | 33.3* | 35.7 | 34.0* |
| Education | | | | | | | | |
| Less than high school | 27.2 | 32.0†† | 28.4 | 33.2†† | 28.8 | 34.2†† | 29.4 | 35.6†† |
| High school grad or GED | 41.4 | 43.1 | 41.2 | 42.9 | 41.8 | 42.9 | 42.8 | 42.7 |
| Some college, no degree | 23.6 | 19.0 | 22.7 | 18.2 | 22.6 | 18.1 | 21.7 | 16.9 |
| College degree | 6.5 | 4.5 | 6.4 | 4.2 | 5.6 | 3.4 | 5.1 | 3.4 |
| Unknown | 1.3 | 1.5 | 1.4 | 1.4 | 1.2 | 1.4 | 1.1 | 1.4 |
| Any smoking during pregnancy | 27.9 | 28.5 | 28.1 | 29.3 | 29.0 | 30.6* | 29.5 | 31.3* |
| Any previous live births | 70.6 | 59.0** | 71.8 | 60.6** | 72.5 | 61.1** | 73.4 | 60.3** |
| Short inter-pregnancy interval | 31.2 | 26.0** | 31.4 | 26.9** | 31.2 | 26.6** | 30.8 | 26.5** |

Table IV.5. (*continued*)

| | Cohort of 1-year-olds | | Cohort of 2-year-olds | | Cohort of 3-year-olds | | Cohort of 4-year-olds | |
|---|---|---|---|---|---|---|---|---|
| | **No WIC** | **WIC** | **No WIC** | **WIC** | **No WIC** | **WIC** | **No WIC** | **WIC** |
| **Child's characteristics** | | | | | | | | |
| Gender is male | 51.7 | 51.7 | 50.9 | 51.6 | 51.1 | 51.8 | 50.9 | 50.7 |
| Multiple birth | 5.1 | 2.6** | 4.4 | 2.4** | 3.3 | 2.8* | 4.0 | 3.2** |
| Gestational age (in weeks) | 38.4 | 38.4 | 38.4 | 38.5* | 38.5 | 38.5 | 38.4 | 38.4 |
| Preterm birth (fewer than 37 weeks) | 11.9 | 10.8** | 10.4 | 11.1 | 10.7 | 11.0 | 11.8 | 11.4 |
| Very preterm birth (32 weeks or fewer) | 1.9 | 2.3* | 1.4 | 2.2** | 1.6 | 2.1* | 2.3 | 2.3 |
| Birthweight (in grams) | 3,204 | 3,203 | 3,203 | 3,210 | 3,202 | 3,223* | 3,199 | 3,199 |
| Low birthweight (fewer than 2500 g) | 9.9 | 9.6 | 8.8 | 9.5 | 8.8 | 9.4 | 9.8 | 9.8 |
| Very low birthweight (fewer than 1500 g) | 1.1 | 1.6** | 0.9 | 1.5** | 0.8 | 1.5** | 1.3 | 1.4 |
| Rural residence | 27.5 | 39.2** | 25.5 | 39.6** | 25.0 | 39.8** | 26.7 | 40.5** |
| Household income less than or equal to 100 percent of the Federal poverty level | 86.5 | 84.3** | 81.6 | 81.8 | 82.6 | 81.5* | 81.0 | 81.2 |
| Mean household income (as a percentage of the Federal poverty level) | 38.4 | 35.7** | 45.8 | 47.6* | 46.7 | 46.9 | 47.6 | 49.1 |
| SNAP enrollment | 83.4 | 86.6** | 84.2 | 88.3** | 84.8 | 88.0** | 83.1 | 87.5** |
| TANF enrollment | 27.9 | 31.5** | 24.6 | 30.3** | 22.7 | 27.9** | 19.5 | 25.5** |
| Aged, blind, and/or disabled Medicaid enrollment category | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.7 | 0.5 | 0.7 |
| Child Welfare Medicaid enrollment category | 0.6 | 1.4** | 0.4 | 1.3** | 0.5 | 1.4** | 0.6 | 1.2** |
| Medicaid managed care beneficiary | 73.7 | 67.0** | 75.5 | 66.2** | 74.7 | 66.4** | 74.1 | 65.8** |
| **Sample size** | **8,596** | **21,295** | **6,632** | **21,833** | **5,789** | **21,243** | **5,419** | **19,391** |

Source: WIC-Medicaid II Database for Missouri, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Missouri continuously enrolled from January to December 2010 and linked with a Vital Records birth certificate.

The table presents the percentage of observations for binary and categorical variables, and presents means for continuous variables. Variables are defined in Table IV.4. Asterisks denote statistically significant differences between WIC participants and nonparticipants from Student's t-tests for dichotomous and continuous variables (* $p$<0.05; ** $p$<0.01), and daggers denote statistically significant chi-squared tests for categorical variables († $p$<0.05; †† $p$<0.01). Percentages across categories may not total 100 percent because of rounding and missing data.

See Appendix D for comparisons of WIC participants and nonparticipants after IPW.

g = grams; GED = general educational development (diploma); IPW = inverse probability weighting; SNAP = Supplemental Nutrition Assistance Program; TANF = Temporary Assistance for Needy Families; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

**Table IV.6. Demographic and socioeconomic characteristics and health risk factors of child WIC participants and nonparticipants in Oklahoma, by age cohort, before IPW**

| | Cohort of 1-year-olds | | Cohort of 2-year-olds | | Cohort of 3-year-olds | | Cohort of 4-year-olds | |
|---|---|---|---|---|---|---|---|---|
| | No WIC (before IPW) | WIC | No WIC (before IPW) | WIC | No WIC (before IPW) | WIC | No WIC (before IPW) | WIC |
| **Mother's characteristics** | | | | | | | | |
| Age at child's birth | | | | | | | | |
| ≤17 years | 5.3 | 5.8†† | 4.9 | 6.6†† | 4.8 | 6.9†† | 4.9 | 6.7†† |
| 18–19 years | 13.7 | 12.5 | 11.5 | 13.4 | 11.2 | 13.2 | 11.2 | 13.0 |
| 20–34 years | 76.6 | 75.5 | 77.9 | 74.2 | 78.8 | 74.3 | 78.5 | 74.7 |
| ≥35 years | 4.4 | 6.2 | 5.7 | 5.8 | 5.2 | 5.6 | 5.5 | 5.6 |
| Race/ethnicity | | | | | | | | |
| Non-Hispanic white | 11.2 | 26.2†† | 9.8 | 24.5†† | 10.7 | 24.4†† | 9.2 | 23.7†† |
| Non-Hispanic black | 65.5 | 55.0 | 66.7 | 56.3 | 66.2 | 55.9 | 66.7 | 56.2 |
| Hispanic | 15.1 | 14.5 | 15.0 | 15.0 | 15.3 | 15.3 | 16.7 | 15.8 |
| Non-Hispanic American Indian Alaskan Native | 5.2 | 2.2 | 6.3 | 2.4 | 5.7 | 2.6 | 5.1 | 2.4 |
| Non-Hispanic Asian Pacific Islander | 1.7 | 1.6 | 1.8 | 1.6 | 1.5 | 1.3 | 1.7 | 1.3 |
| Multiple races, other race, or unknown | 1.3 | 0.5 | 0.3 | 0.2 | 0.5 | 0.4 | 0.5 | 0.5 |
| Married | 40.1 | 41.1 | 42.6 | 41.2 | 44.2 | 41.2** | 44.4 | 42.6 |
| Education | | | | | | | | |
| Less than high school | 26.8 | 35.1†† | 26.5 | 35.3†† | 27.8 | 37.1†† | 28.6 | 36.7†† |
| High school grad or GED | 43.7 | 42.4 | 47.1 | 43.0 | 46.1 | 43.0 | 43.7 | 43.3 |
| Some college, no degree | 22.8 | 17.3 | 19.5 | 16.9 | 19.8 | 15.2 | 20.9 | 15.6 |
| College degree | 6.2 | 4.7 | 6.4 | 4.1 | 5.7 | 4.1 | 6.1 | 3.8 |
| Unknown | 0.5 | 0.5 | 0.5 | 0.7 | 0.6 | 0.7 | 0.7 | 0.5 |
| Any smoking during pregnancy | 21.5 | 19.2** | 23.4 | 21.1** | 24.5 | 21.7** | 24.7 | 21.5** |
| Any previous live births | 65.5 | 62.3** | 69.0 | 62.4** | 69.8 | 63.5** | 69.0 | 62.6** |
| Short inter-pregnancy interval | 25.2 | 21.4** | 26.5 | 22.8** | 25.7 | 21.9** | 24.9 | 21.1** |

Table IV.6. (*continued*)

| | Cohort of 1-year-olds | | Cohort of 2-year-olds | | Cohort of 3-year-olds | | Cohort of 4-year-olds | |
|---|---|---|---|---|---|---|---|---|
| | No WIC (before IPW) | WIC | No WIC (before IPW) | WIC | No WIC (before IPW) | WIC | No WIC (before IPW) | WIC |
| **Child's characteristics** | | | | | | | | |
| Gender is male | 51.3 | 51.7 | 51.1 | 50.9 | 51.2 | 51.7 | 51.9 | 51.6 |
| Multiple birth | 3.0 | 3.1 | 3.0 | 3.0 | 2.5 | 3.0 | 2.9 | 2.7 |
| Gestational age (in weeks) | 38.3 | 38.3* | 38.4 | 38.3** | 38.4 | 38.4 | 38.5 | 38.4* |
| Preterm birth (fewer than 37 weeks) | 11.9 | 11.3 | 11.7 | 11.0 | 10.9 | 10.8 | 11.2 | 10.9 |
| Very preterm birth (32 weeks or fewer) | 2.0 | 2.3 | 2.0 | 2.3 | 1.9 | 2.3 | 1.9 | 2.0 |
| Birthweight (in grams) | 3,198 | 3,188 | 3,195 | 3,189 | 3,204 | 3,200 | 3,219 | 3,209 |
| Low birthweight (fewer than 2500 g) | 9.7 | 9.8 | 9.5 | 9.2 | 9.1 | 9.1 | 8.9 | 9.0 |
| Very low birthweight (fewer than 2500 g) | 1.3 | 1.6 | 1.1 | 1.5 | 1.0 | 1.3 | 1.2 | 1.3 |
| Rural residence | 40.9 | 34.3** | 41.5 | 35.5** | 41.2 | 34.8** | 39.1 | 35.3** |
| Household income is less than or equal to 100 percent of the Federal poverty level | 81.9 | 80.2* | 79.5 | 79.8 | 78.7 | 79.3 | 77.2 | 79.7** |
| Mean household income (as a percentage of the Federal poverty level) | 54.9 | 51.1** | 56.4 | 55.7 | 57.4 | 56.4 | 57.6 | 58.4 |
| TANF enrollment | 99.0 | 99.1 | 98.4 | 98.6 | 97.7 | 98.4* | 97.8 | 98.0 |
| Aged, blind, and/or disabled Medicaid enrollment category | 0.6 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.8 |
| Child Welfare Medicaid enrollment category | 3.7 | 3.2 | 3.7 | 3.5 | 3.5 | 3.4 | 3.1 | 3.6 |
| **Sample size** | **5,175** | **12,116** | **3,908** | **12,066** | **3,628** | **12,152** | **3,205** | **11,047** |

Source: WIC-Medicaid II Database for Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Missouri continuously enrolled from January to December 2010 and linked with a Vital Records birth certificate.

The table presents the percentage of observations for binary and categorical variables, and presents means for continuous variables. Variables are defined in Table IV.4. Asterisks denote statistically significant differences between WIC participants and nonparticipants from Student's t-tests for dichotomous and continuous variables (* $p$<0.05; ** $p$<0.01), and daggers denote statistically significant chi-squared tests for categorical variables († $p$<0.05; †† $p$<0.01). Percentages across categories may not total 100 percent because of rounding and missing data.

See Appendix D for comparisons of WIC participants and nonparticipants after IPW.

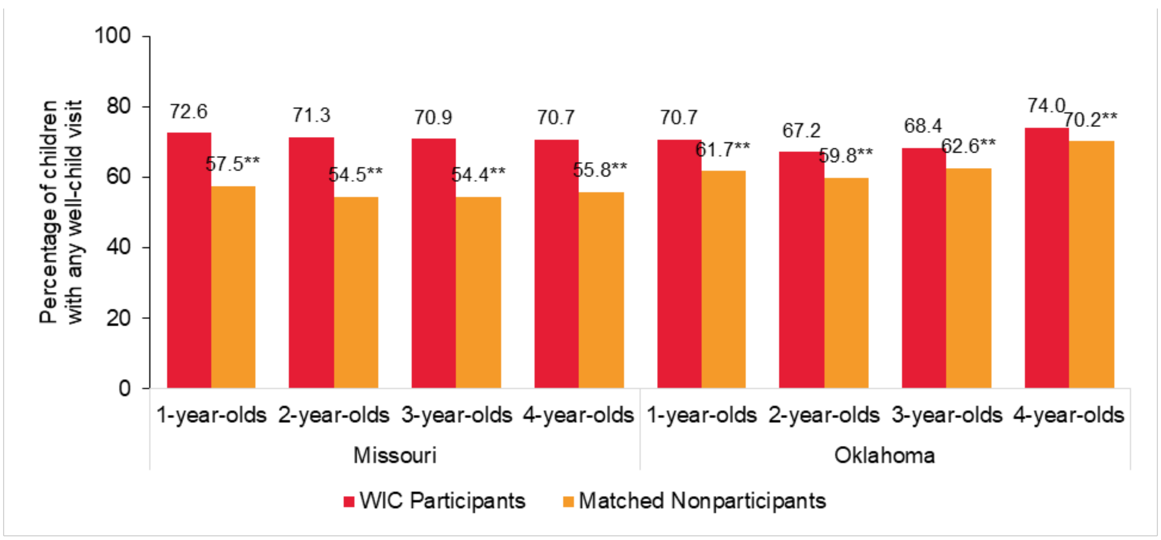
g = grams; GED = general educational development (diploma); IPW = inverse probability weighting; SNAP = Supplemental Nutrition Assistance Program; TANF = Temporary Assistance for Needy Families; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.

## C. Associations between child WIC participation and study outcomes

### 1. Health care utilization

In both Missouri and Oklahoma, WIC participation was associated with increased health care utilization (Figure IV.1).[60] In both States and across age cohorts, children with any WIC participation were more likely to have had a **well-child visit** than the matched comparison group, and all the differences were statistically significant. As seen in Figure IV.1, the estimated association between any child WIC participation and having had at least one well-child visits in Missouri ranged from 14.9 percentage points for the 4-year-old cohort (70.7 versus 55.8 percent) to 16.8 percentage points for the 2-year-old cohort (71.3 versus. 54.5 percent). These differences between WIC participants and nonparticipants were large—more than 0.3 standard deviations for all four age groups. In Oklahoma, differences between WIC participants and nonparticipants were larger among the 1- and 2-year-old cohorts than for older cohorts. Among 1-year-olds in Oklahoma, 70.7 percent of WIC participants had a well-child visit, compared with 61.7 percent of the matched comparison group—a difference of 9 percentage points. The differences between participants and nonparticipants were smaller, but also statistically significant for the other age cohorts.

**Figure IV.1. Estimates of the association between any child WIC participation and the percentage of children with a well-child visit, by State and age cohort**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Missouri and Oklahoma continuously enrolled between January and December 2010 that were linked with a Vital Records birth certificate.

The matched comparison group of nonparticipants was constructed with IPW. The propensity score model included the full set of covariates shown in Table IV.4.

The outcome measure is a binary indicator of having one or more well-child visits during calendar year 2010.

Statistical tests for the differences between WIC participants and nonparticipants were adjusted for multiple comparisons using methods from Hothorn et al. (2008, 2013).

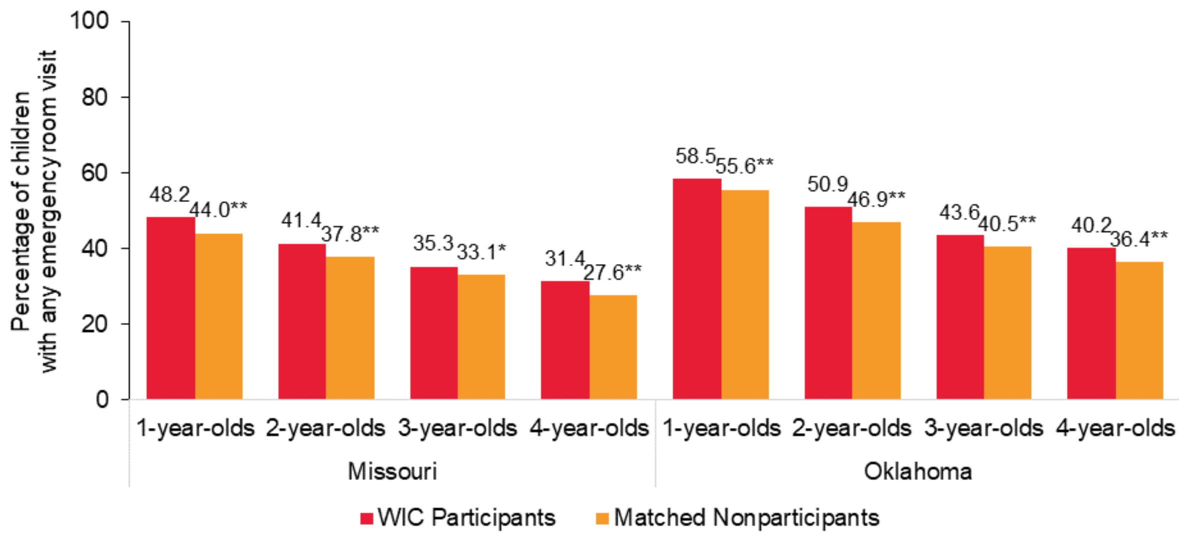
** Difference is statistically significant at the *p*<0.01 level.

IPW inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

[60] Appendix G, Table G.5 presents detailed findings for all the primary outcomes, for each age cohort, including the mean outcome for child WIC participants and matched nonparticipants, the difference in means, SEs, effect-sizes, and sample sizes.

Children who participated in WIC were also more likely than nonparticipants to have **visited the ER** (Figure IV.2). Differences between WIC participants and nonparticipants were statistically significant for all four age cohorts in both States. In Missouri, the difference between WIC participants and nonparticipants in the likelihood of an ER visit ranged from 2.3 percentage points among 3-year-olds to 4.2 percentage points among 1-year-olds.[61] In Oklahoma, 1- and 3-year-old WIC participants were 3.0 percentage points more likely to have an ER visit at least once during calendar year 2010. In the 2- and 4-year-old cohorts, the difference was about 4.0 percentage points. In both States the proportion of children with at least one ER visit during calendar year 2010 decreased as age increased.

**Figure IV.2. Estimates of the association between any child WIC participation and the percentage of children with an ER visit, by State and age cohort**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Missouri and Oklahoma continuously enrolled between January and December 2010 that were linked with a Vital Records birth certificate.

The matched comparison group of nonparticipants was constructed with IPW. The propensity score model included the full set of covariates shown in Table IV.4.

The outcome measure is a binary indicator of having one or more ER visits during calendar year 2010.

Statistical tests for the differences between WIC participants and nonparticipants were adjusted for multiple comparisons using methods from Hothorn et al. (2008, 2013).

*/** Difference is statistically significant at the *p*<0.05/0.01 level.

ER = emergency room; IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

Similar patterns emerged among **secondary health care utilization outcome measures**, although the differences were not always statistically significant for all four age cohorts (Appendix G, Tables G.6 and G.7). For both States, the results indicate that a positive association existed between WIC participation and the percentage of children with an EPSDT visit, the number of visits with an immunization, the number of well-child visits, and the number of ER

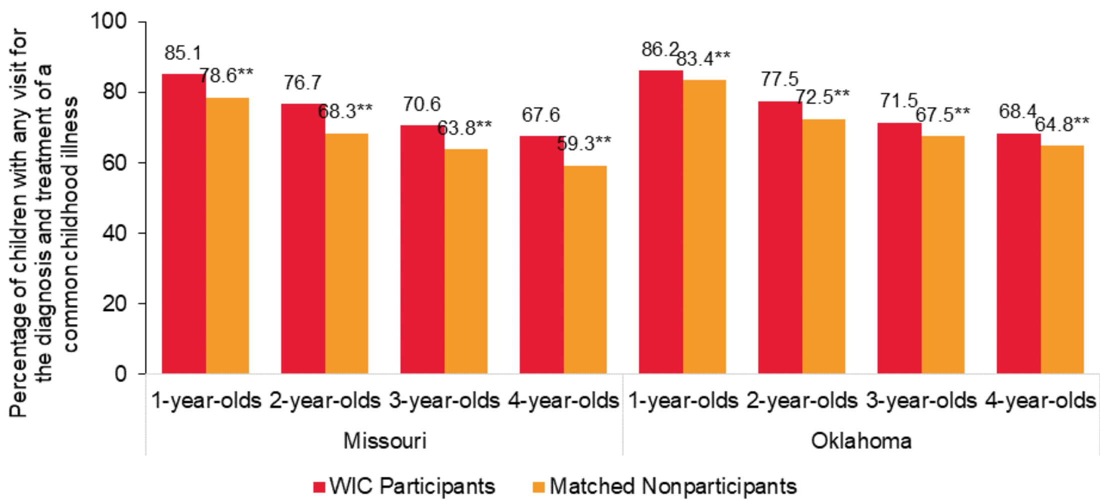
[61] To some readers, the percentages of children with ER visits might appear high. However, these data are roughly in-line with national rates. According to the National Center for Health Statistics (2014, Table 86), in 2010, 35.5 percent of Medicaid recipients younger than 6 years had one or more ER visits.

visits. There was less indication of an association between WIC participation and the utilization of hospital services. In Missouri, there was also evidence of an association between WIC participation and the number of dental visits.

### 2. Diagnosis and treatment of common childhood illnesses

Child WIC participation was associated with an increased probability of **diagnosis and treatment of common childhood illnesses** (Figure IV.3). Across age cohorts, children with any WIC participation in both States were more likely than matched nonparticipants to have received a diagnosis or treatment for one of six common childhood illnesses. Differences across age cohorts ranged from 3 to 5 percentage points in Oklahoma and 6 to 8 percentage points in Missouri. In both States, the largest difference was among 2-year-olds. In Missouri, 76.7 percent of children who participated in WIC in the 2-year-old cohort had a visit that involved diagnosis or treatment, compared with 68.3 percent of the matched comparison group (a difference of 8.5 percentage points). In Oklahoma, the difference was 5 percentage points (77.5 versus 72.5 percent).

**Figure IV.3. Estimates of the association between any child WIC participation and the percentage of children with a visit for the diagnosis and treatment of a common childhood illness, by State and age cohort**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Missouri and Oklahoma continuously enrolled between January and December 2010 that were linked with a Vital Records birth certificate.

The matched comparison group of nonparticipants was constructed with IPW. The propensity score model included the full set of covariates shown in Table IV.4.

The outcome variable measures the percentage of children with at least one Medicaid claim for otitis media (ear infection), upper respiratory infection, lower respiratory infection, asthma, iron deficiency anemia, gastroenteritis, or allergies.

** Differences were statistically significant at the $p < .01$ level.

IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

Findings from the analyses of **secondary outcome measures** in this domain indicate that children with any WIC participation were more likely than children in the matched comparison group to have been diagnosed or treated for each type of illness (Appendix G, Table G.8). This is consistent with the findings presented in Figure IV.3. In Missouri, differences were statistically significant across all four age cohorts for all types of illnesses. In Oklahoma, on the other hand, differences between WIC participants and nonparticipants in the rates of diagnosis and treatment were not statistically significant for all age cohorts for all types of illnesses. For example, differences in the percentage of children with a diagnosis and treatment for otitis media and gastroenteritis were statistically significant only for the 1- and 2-year-old cohorts, and for allergy, the differences were statistically significant only for the 1-, 2-, and 3-year-old cohorts.

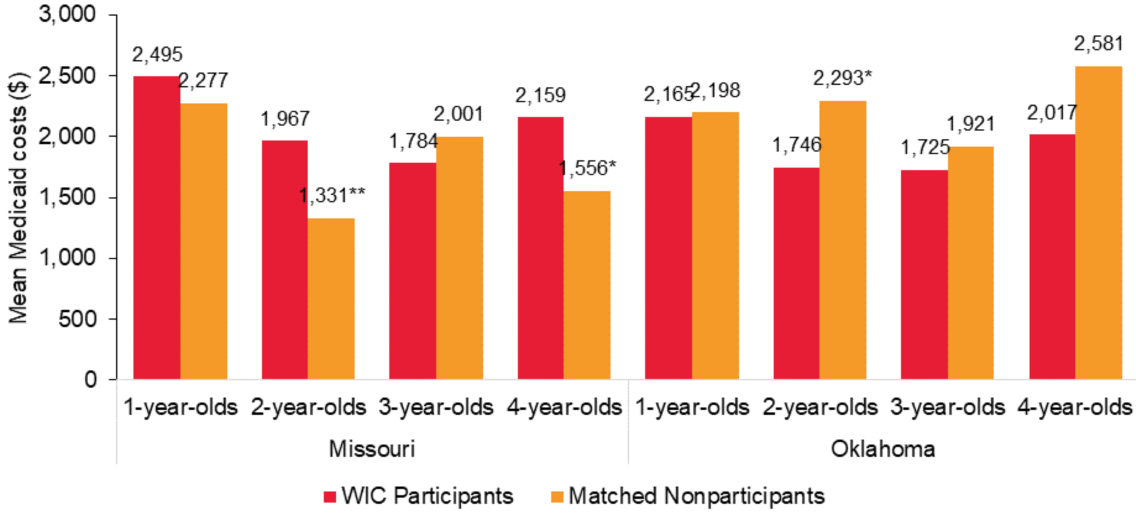
### 3. Medicaid costs

Estimates of the association between child WIC participation and **total Medicaid costs** varied substantially by State. Among fee-for-service beneficiaries in Missouri, total Medicaid costs for calendar year 2010 were, generally *higher*, on average, for WIC participants than nonparticipants, and this difference was statistically significant for the 2- and 4-year-old cohorts (Figure IV.4).[62] For the 2-year-olds, total Medicaid costs for WIC participants were $637 higher than nonparticipants ($1,967 versus $1,331). For the 4-year-olds, total Medicaid costs for WIC participants were $603 higher ($2,159 versus $1,556).

In Oklahoma, total Medicaid costs for calendar year 2010 were *lower,* on average, for WIC participants than nonparticipants, and this difference was statistically significant for only one cohort (2-year-olds). For the 2-year-olds, total Medicaid costs for WIC participants were $547 lower than nonparticipants ($1,746 versus $2,293). The findings for Oklahoma are inconsistent with findings for Missouri and findings from the Buescher study, both of which found that WIC participation was associated with significantly higher Medicaid costs. The study team conducted several supplementary analyses to explore potential explanations for the inconsistent finding in the two study States. As discussed in the following sections, these supplementary analyses indicated that the association between child WIC participation and Medicaid costs in Oklahoma was sensitive to the treatment of outliers (particularly outliers with high inpatient Medicaid costs). Analyses that looked at the distribution of Medicaid costs showed that, across much of the distribution in both States, Medicaid costs were generally *higher* for WIC participants than for matched nonparticipants. Similarly, analyses that used the logarithm of costs found that Medicaid costs—in both States and for all four age cohorts—were significantly higher for WIC participants than for nonparticipants.

[62] As explained in Chapter II, analysis of Medicaid costs in Missouri was limited to fee-for-service beneficiaries. Approximately 68 percent of Medicaid recipients in Missouri are enrolled in Medicaid managed care. Many claims submitted by these managed care plans did not include information about actual costs of services.

**Figure IV.4. Estimates of the association between any child WIC participation and Medicaid costs, by age cohort**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Missouri and Oklahoma continuously enrolled between January and December 2010 that were linked with a Vital Records birth certificate.

The matched comparison group of nonparticipants was constructed with IPW. The propensity score model included the full set of covariates shown in Table IV.4.

Sensitivity analyses indicated that findings for Medicaid costs, especially in Oklahoma, were not robust to alternative methodological approaches. For this reason, results presented in this figure should be interpreted with caution. See the text for details.

The analysis of Medicaid costs includes only fee-for-service recipients. Approximately 68 percent of Medicaid recipients in Missouri are enrolled in Medicaid managed care. Many claims submitted by these managed care plains did not include information about actual costs of services.

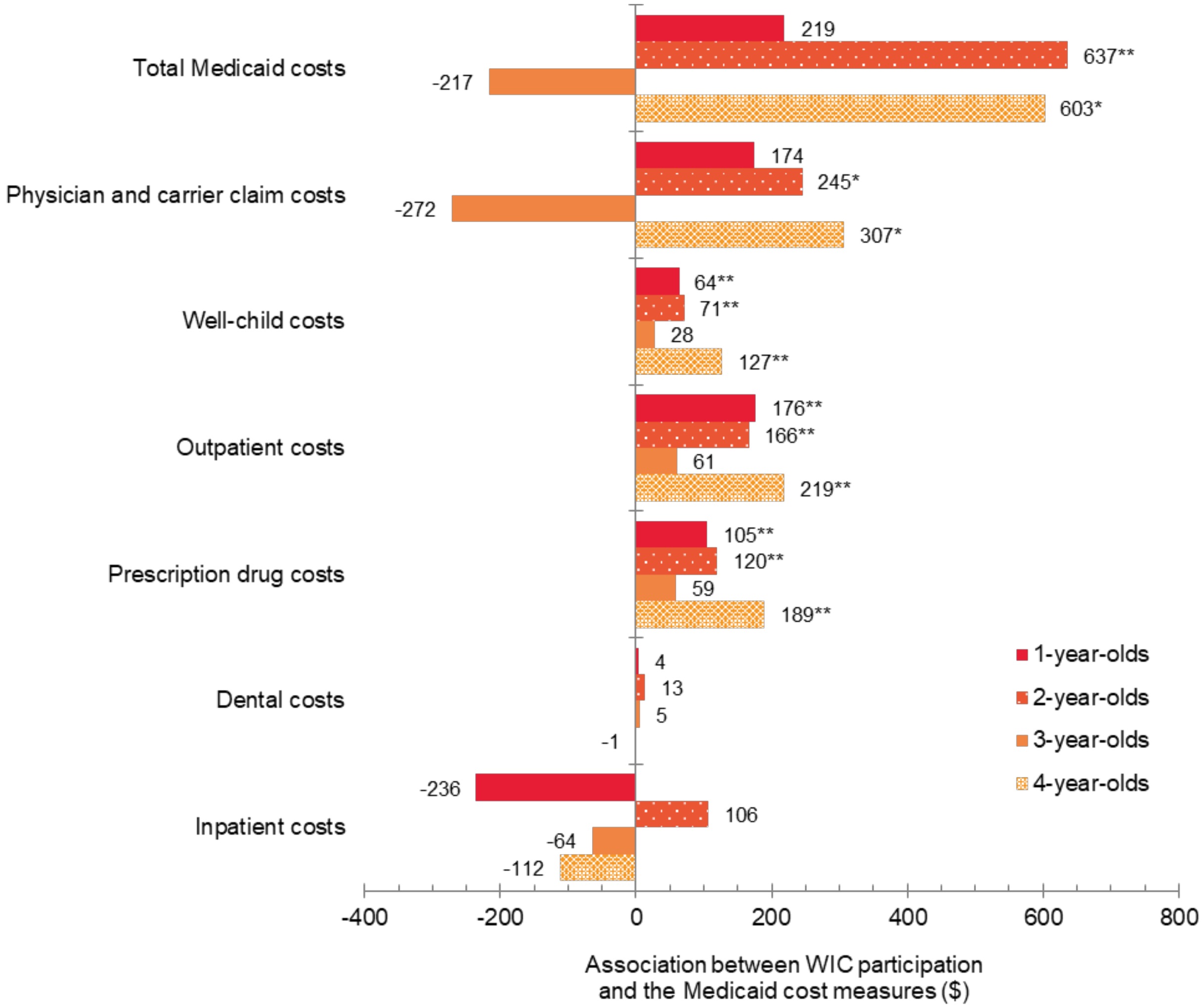
*/** Difference is statistically significant at the $p<0.05/0.01$ level.

IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

**Subcategories of Medicaid costs**. Medicaid costs were disaggregated to identify costs associated with inpatient services and costs associated with non-inpatient services (such as office visits, ER visits, prescription medications, and so on). These disaggregated data—summarized in Figures IV.5 and IV.6—provide several insights. In Missouri, costs for well-child visits (including EPSDT services), outpatient services, and prescription drugs were consistently higher for WIC participants than for nonparticipants, and these differences were statistically significant for three of the four age cohorts (all but 3-year-olds; Figure IV.5). The same general pattern was observed for physician and carrier claims although, for this subcategory of Medicaid costs, the difference between WIC participants and nonparticipants was not statistically significant for 1-year-olds. There were no significant differences between WIC participants and nonparticipants in Missouri in costs for dental visits or inpatient hospital stays.

In Oklahoma, costs for well-child visits were also consistently higher for WIC participants than nonparticipants and these differences were statistically significant for all four age cohorts (Figure IV.6). However, the magnitude of significant differences between WIC participants and nonparticipants was smaller in Oklahoma than in Missouri (differences of $6 to $30 for well-child visits in Oklahoma versus $64 to $127 in Missouri). Moreover, in contrast to the pattern observed in Missouri, there were no statistically significant differences between WIC participants and nonparticipants in Oklahoma in physician and carrier claims costs, outpatient costs, or prescription drug costs. In Missouri, for all three of these cost subcategories, costs were higher for WIC participants than nonparticipants.

**Figure IV.5. Estimates of the association between any child WIC participation and Medicaid costs in Missouri, by claim type and age cohort**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Missouri continuously enrolled between January and December 2010 that were linked with a Vital Records birth certificate. Outcome measures are defined in Table IV.3. Well-child costs is a subset of the physician and carrier claim costs; well-child costs include the cost of EPSDT visits.

The figure summarizes results from Appendix G, Table G.MO.9. A positive association indicates that WIC participants had *higher* costs than nonparticipants, and a negative association indicates that WIC participants had *lower* costs than nonparticipants. Results may not match Figure IV.4 due to rounding.

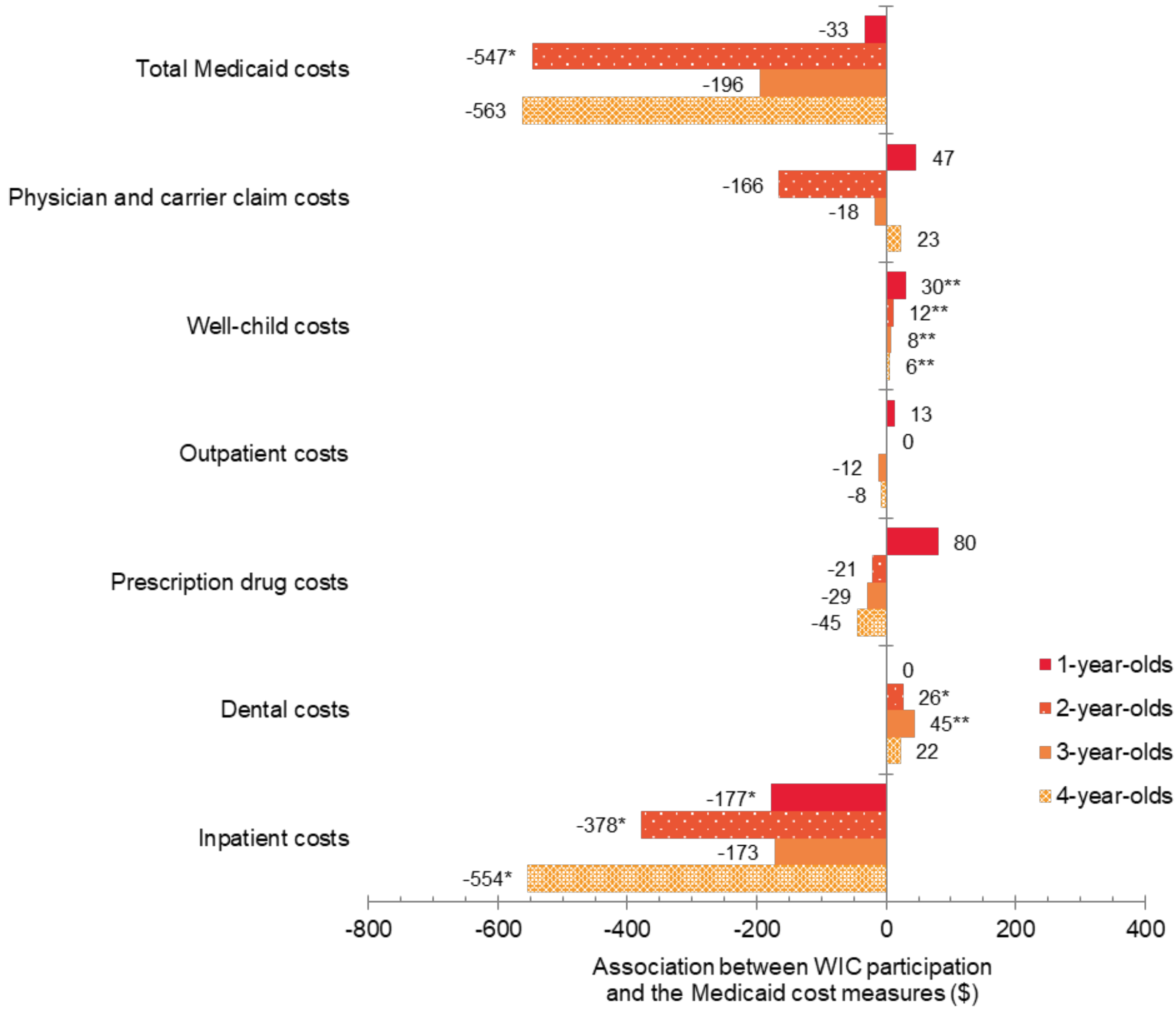
The matched comparison group of nonparticipants was constructed with IPW. The propensity score model included the full set of covariates shown in Table IV.4. Each estimate was obtained from a separate model. Statistical tests were not adjusted for multiple comparisons.

The analysis of Medicaid costs includes only fee-for-service recipients. Approximately 68 percent of Medicaid recipients in Missouri are enrolled in Medicaid managed care. Many claims submitted by these managed care plains did not include information about actual costs of services.

*/** Difference is statistically significant at the $p$<0.05/0.01 level.

IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

**Figure IV.6. Estimates of the association between any child WIC participation and Medicaid costs in Oklahoma, by claim type and age cohort**




Sources: WM-II databases for Missouri and Oklahoma, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Oklahoma continuously enrolled between January and December 2010 that were linked with a Vital Records birth certificate. Outcome measures are defined in Table IV.3. Well-child costs is a subset of the physician and carrier claim costs; well-child costs include the cost of EPSDT visits.

The figure summarizes results from Appendix G, Table G.OK.9. A positive association indicates that WIC participants had *higher* costs than nonparticipants, and a negative association indicates that WIC participants had *lower* costs than nonparticipants. Results may not match Figure IV.4 due to rounding.

The matched comparison group of nonparticipants was constructed with IPW. The propensity score model included the full set of covariates shown in Table IV.4. Each estimate was obtained from a separate model. Statistical tests were not adjusted for multiple comparisons.

*/** Difference is statistically significant at the $p$<0.05/0.01 level.

IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

Although differences in these subcategories of Medicaid costs provide some insight into patterns that might explain the different findings for Medicaid costs in Missouri and Oklahoma, the real driver appears to be inpatient costs. In Missouri, there was no significant difference between WIC participants and nonparticipants in inpatient (hospital) costs (Figure IV.5). In Oklahoma, on the other hand, WIC participants in all but one cohort (3-year-olds) had significantly *lower* inpatient costs than nonparticipants. Differences were −$378 for 2-year-olds and −$554 for 4-year-olds. Both of these differences are sizable enough that differences in *inpatient* costs explain the results for *total* Medicaid costs observed for these two cohorts (see Figure IV.4). The fact that hospitalizations are fairly rare among children (2 to 5 percent of children had one or more hospitalizations in 2010, depending on the age cohort, as shown in Appendix G, Table G.6) raises the concern that the estimated difference in costs could be driven by outliers. In particular, it is possible that there are a small number of children in the matched comparison group in Oklahoma with particularly high inpatient costs. To explore this issue, the study team implemented two additional sensitivity analyses.

First, the models were reestimated after the measure of total Medicaid costs was Winsorized (trimmed) at various levels (see Appendix H for details). Trimming the sample in this way causes the highest-cost children (outliers) to have less influence on the analyses. In Missouri, trimming the outliers had no effect on findings for three of the four cohorts, indicating that higher total Medicaid costs for WIC participants in Missouri, relative to nonparticipants, were not driven by outliers. For the 3-year-old cohort, the lack of a significant difference between WIC participants and nonparticipants in total Medicaid costs (Figure IV.4) was strongly influenced by a small number of children in the matched comparison group with unusually high costs (particularly costs for physician and other carrier claims). When the model was reestimated with the measure of total costs Winsorized at various levels, total Medicaid costs for 3-year-olds were higher for WIC participants than nonparticipants, in keeping with the pattern observed for the other age cohorts, but the difference was not statistically significant. Analyses of the logarithm of Medicaid costs indicated that, on average, total Medicaid costs for child WIC participants in Missouri were 6 to 8 percent higher than total Medicaid costs for nonparticipants.

In Oklahoma, trimming the outliers caused the difference between WIC participants and nonparticipants in the 2-year-old cohort to become small and were not statistically significant, which indicates that outliers were driving the statistically significant difference observed between the two groups (Figure IV.4). Similarly, differences between WIC participants and nonparticipants in the 3- and 4-year-old cohorts became smaller (closer to zero). These findings indicate that the presence of outliers also (partially) explains why total Medicaid costs were lower for WIC participants than nonparticipants for these three age cohorts in Oklahoma (although the differences were not statistically significant). Analyses of the logarithm of Medicaid costs indicate that Medicaid costs for child WIC participants in Oklahoma were, on average, 6 to 7 percent higher than the costs for nonparticipants.

As a second sensitivity analysis, the study team also calculated differences in Medicaid costs between WIC participants and nonparticipants across the distribution of Medicaid costs, from the 5th to the 95th percentiles in increments of 5 percent (Appendix H, Figure H.1). In Missouri, the estimated quantile treatment effect models for each cohort indicate that WIC participation was associated with higher Medicaid costs for most quantiles (that is, most children) in all four age cohorts. The estimate at the very top of the distribution for the 3-year-old cohort was imprecisely estimated and should thus be interpreted with caution.

In Oklahoma, quantile treatment effect models also indicate that WIC participation was associated with higher Medicaid costs for most quantiles (that is, most children) in all four age cohorts, but not necessarily for the highest-cost quantiles. Estimates for the highest quantiles are very uncertain—SEs are very large for the upper quantiles (the 95th quantile is represented by the data point furthest to the right in the graph). These findings suggest that the reason WIC participants in Oklahoma had *lower* average Medicaid costs was due to differences between the two groups in the upper tail of the cost distribution. For the rest of the cost distribution, WIC participation was associated with higher Medicaid costs, similar to the results from Missouri.

Considering all of these findings together, there is strong evidence that child WIC participants in Missouri had higher Medicaid costs and, consistent with findings for other outcomes (Figures IV.1 to IV.4), that these higher costs were associated with greater diagnosis and treatment of common childhood illnesses and utilization of important health care services, including well-child visits, ER visits, and EPSDT services. The pattern of findings for most of the outcomes examined in this analysis was consistent in Oklahoma, but the main finding for total Medicaid costs was not consistent. Exploratory analyses using disaggregated Medicaid claims data revealed that this apparently anomalous finding was largely due to a small number of nonparticipant children in Oklahoma with high inpatient costs, which drove up the overall average cost for this group (that is, outliers in Medicaid costs had a strong influence on the results). Analysis with quantile treatment effect models and the logarithm of Medicaid costs found that WIC participation was associated with higher Medicaid costs for *most* children in Oklahoma, which is consistent with the findings for Missouri and with the Buescher study.

## D. Supplemental analyses

The study team conducted a number of supplemental analyses to explore secondary questions about the associations between child WIC participation and the various outcomes. The analyses examined these associations by length of WIC participation and among subgroups of children defined by mother's age and household income.

### 1. Estimates by length of WIC participation

These analyses explored whether outcomes differed for children who participated in WIC for different lengths of time, building on the approach used in the Buescher study. Within each age cohort, the sample of WIC participants was separated into three groups—low, medium, and high participation—based on the length of their participation, and a matched comparison group of nonparticipants was constructed for each group using IPW. Table IV.7 presents results of this dose-response analysis. Given the more exploratory nature of these analyses, and the fact that controls for multiple comparisons were not included, these results should be interpreted with caution.

In both States, significant differences between WIC participants and nonparticipants for several outcomes were largest among children who participated in WIC for longer periods of time. For example, the first row of Table IV.7 shows statistically significant differences between children with high levels of participation in WIC and a matched comparison group of nonparticipants in the percentage of 1-year-old children with a well-child visit (14.4 percentage points in Oklahoma and 19.9 percentage points in Missouri). The differences in this outcome were also statistically significant among 1-year-old children with medium levels of WIC participation, but the magnitude of the differences between WIC participants and nonparticipants were smaller (4.5 percentage points in Oklahoma and 10.8 percentage points in Missouri).

For ER visits, there were statistically significant differences in utilization between WIC participants and nonparticipants across all three dose-response groups (low, medium, and high participation), but no evidence that length of WIC participation influenced the size of the difference.[63]

The study team also estimated a series of models to examine whether the association between WIC participation and health care utilization and Medicaid costs varied if children participated at different ages. Results were imprecise, but there was no indication that the associations between WIC participation and these outcomes were larger or smaller if children participated when they were younger, relative to when they were older.

### 2. Subgroup analyses

Subgroup analyses explored associations between WIC participation and the primary outcomes among subgroups of children defined by mother's age and household income.

#### a. Age of mother

For the most part, findings reported for the primary outcomes were consistent with the main analyses when outcomes were estimated separately for children whose mothers were younger than 18 at the time of a child's birth and children whose mothers were 18 years or older at the time of a child's birth. In both States, differences between WIC participants and the matched comparison group for children with older mothers closely mirrors the differences between the two groups estimated with the full sample (Appendix G, Table G.10). That is, among children whose mothers were 18 or older when a child was born (older mothers), WIC participants were more likely than matched nonparticipants to have well-child and ER visits, and to be diagnosed or treated for a common childhood illness. Further, child WIC participation was associated with higher Medicaid costs in some age cohorts in Missouri.[63] Results for the subgroup of children with mothers who were younger than 18 at the time of a child's birth were generally similar in direction, but fewer results were statistically significant. This is likely due, at least in part, to the fact that relatively few children in the sample had mothers who were less than 18 at the time of their births. For this reason, estimates for this subgroup are not very precise.

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[63] Readers should note that outliers could have driven estimated differences in Medicaid costs in Oklahoma and for one age cohort in Missouri, as discussed in Section C.3.

## Table IV.7. Estimates of the association between child WIC participation and the primary outcomes by State, length of WIC participation, and age cohort

| | | Missouri | | | Oklahoma | | |
|---|---|---|---|---|---|---|---|
| | | Low WIC participation | Medium WIC participation | High WIC participation | Low WIC participation | Medium WIC participation | High WIC participation |
| Outcome | Age cohort | (1) | (2) | (3) | (4) | (5) | (6) |
| **Health care utilization** | | | | | | | |
| Any well-child visits (%) | 1-year-olds | 8.10** (0.87) | 10.79** (0.84) | 19.84** (0.73) | -1.25 (1.21) | 4.49** (1.08) | 14.42** (0.98) |
| | 2-year-olds | 6.60** (0.90) | 12.76** (0.94) | 25.88** (0.89) | 0.76 (1.20) | 5.70** (1.18) | 11.98** (1.20) |
| | 3-year-olds | 7.16** (0.90) | 15.08** (0.99) | 26.55** (0.99) | 1.28 (1.15) | 4.68** (1.17) | 10.30** (1.26) |
| | 4-year-olds | 7.29** (0.90) | 14.54** (1.02) | 25.03** (1.09) | 2.00 (1.09) | 3.15** (1.17) | 6.85** (1.33) |
| Any ER visits (%) | 1-year-olds | 3.16** (0.90) | 3.92** (0.89) | 4.83** (0.77) | 2.51* (1.25) | 4.70** (1.14) | 2.43* (1.07) |
| | 2-year-olds | 2.59** (0.89) | 4.18** (0.94) | 4.02** (0.88) | 4.36** (1.22) | 6.32** (1.21) | 2.45 (1.27) |
| | 3-year-olds | 1.71 (0.87) | 3.11** (0.99) | 2.19* (0.96) | 3.61** (1.17) | 3.81** (1.22) | 2.10 (1.33) |
| | 4-year-olds | 3.11** (0.84) | 3.89** (0.94) | 4.81** (1.02) | 4.72** (1.17) | 4.11** (1.29) | 3.03* (1.51) |
| **Diagnosis and treatment of common childhood illnesses** | | | | | | | |
| Any visit for the diagnosis and treatment of a common childhood illness (%)[a] | 1-year-olds | 4.67** (0.73) | 5.66** (0.70) | 7.72** (0.63) | 0.26 (0.96) | 2.65** (0.84) | 3.65** (0.78) |
| | 2-year-olds | 5.32** (0.83) | 7.01** (0.86) | 11.22** (0.82) | 1.73 (1.07) | 4.82** (1.06) | 6.71** (1.13) |
| | 3-year-olds | 2.94** (0.87) | 6.82** (0.94) | 10.21** (0.95) | 2.51* (1.10) | 2.86* (1.14) | 6.39** (1.28) |
| | 4-year-olds | 4.24** (0.89) | 7.60** (1.00) | 13.65** (1.10) | 2.28* (1.13) | 3.21** (1.24) | 5.31** (1.47) |

Table IV.7. (*continued*)

| | | Missouri | | | Oklahoma | | |
|---|---|---|---|---|---|---|---|
| | | Low WIC participation | Medium WIC participation | High WIC participation | Low WIC participation | Medium WIC participation | High WIC participation |
| **Outcome** | **Age cohort** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| **Medical costs** | | | | | | | |
| Total Medicaid costs ($)[b] | 1-year-olds | 5<br>(696) | 599<br>(544) | 171<br>(308) | -55<br>(211) | -88<br>(192) | -12<br>(143) |
| | 2-year-olds | 829*<br>(345) | 459*<br>(195) | 640**<br>(173) | -585<br>(371) | -572<br>(307) | -488<br>(271) |
| | 3-year-olds | -194<br>(429) | -352<br>(342) | -210<br>(459) | -286<br>(179) | -342*<br>(164) | -69<br>(205) |
| | 4-year-olds | 438<br>(362) | 650*<br>(318) | 712*<br>(341) | -194<br>(235) | -559<br>(313) | -397<br>(228) |

Source: WM-II databases for Oklahoma and Missouri, constructed by Mathematica Policy Research.

Notes: Based on Medicaid beneficiaries in Oklahoma and Missouri continuously enrolled between January and December 2010 that were linked with a Vital Records birth certificate. Outcome measures are defined in Table IV.3.

Each column presents the difference in the outcomes between a group of WIC participants (that is, WIC participants with high, medium, and low participation in columns 1, 2, and 3, respectively) and a corresponding matched comparison group of nonparticipants, where the matched comparison group was constructed with IPW. The propensity score model included gestational age and the full set of covariates shown in Table IV.4.

Robust standard errors are in parentheses. Asterisks indicate statistically significant differences between WIC participants and nonparticipants at the $p < .01$ (**) and $p < .05$ (*) levels, where tests for statistical significance in the health care utilization domain did *not* account for multiple comparisons.

[a] Otitis media (ear infection), upper respiratory infection, lower respiratory infection, asthma, iron deficiency anemia, gastroenteritis, or allergies.

[b] For Total Medicaid costs with the 4-year-old cohort, the table presents an estimate obtained from a regression (not IPW).

ER = Emergency room; IPW = inverse probability weighting; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; WM-II = WIC-Medicaid II Feasibility Study.

### b. Household income

To examine whether associations between WIC participation and the primary outcomes varied by income, the study team estimated outcomes separately for children with household incomes less than 133 percent of the FPL and children with household incomes greater than or equal to 133 percent of the FPL.[64] A second set of analyses grouped children into four income quantiles. Findings from these analyses did not reveal strong evidence that the associations between WIC participation and the primary outcomes varied consistently by household income (Appendix G, Table G.11). With a few exceptions, the associations for each income subgroup mirrored the findings from the main analysis, although some of the differences in the subgroup analyses were not statistically significant. That is, in each income subgroup, the point estimates indicated that WIC participants were more likely to have had a well-child visit, an ER visit, and a visit involving the diagnosis and treatment of a common childhood illness.

## E. Checks on the robustness and external validity of the main analyses

The study team conducted multiple robustness checks to confirm the accuracy of the main results and explore implications of data limitations on the generalizability of the findings. Appendix H presents results of key analyses. The results can be broadly characterized as demonstrating robustness across plausible alternative methodologies and when alternative sample inclusion or exclusion criteria were used. However, when the analysis was repeated using Winsorized (trimmed) measures of Medicaid costs or the logarithm of costs, the results suggested that outliers might be partially driving the results with untransformed measures of Medicaid costs (as discussed in Section C.3).

The study team checked for heterogeneity in the associations between WIC participation and study outcomes among children who were statistically more or less likely to participate in WIC as a child using subclassification on the propensity score. In this analysis, the sample was partitioned into 10 subclasses based on each child's estimated propensity scores. Then, mean outcomes were compared within each subclass. For all outcomes for most cohorts, hypothesis tests in both States failed to reject the null hypothesis that associations between WIC participation and the primary outcome measures were the same across all 10 subclasses. Even when the associations differed across subclasses, there was no clear pattern (Appendix Table G.12).

Two sets of robustness checks addressed the limitations of the Missouri data. As discussed in Chapter II, the Medicaid claims data in Missouri did not include costs for beneficiaries enrolled in Medicaid managed care, about 68 percent of children. To address this issue, the study team first compared the characteristics of managed care and fee-for-service beneficiaries As shown in Appendix H, there were some differences between the characteristics of fee-for-service beneficiaries (for whom Medicaid costs are available) and managed care beneficiaries (for whom costs are unavailable). For example, managed care beneficiaries are less likely to reside in rural areas and more likely to be black (consistent with the fact that managed care enrollment is determined by county of residence, and the managed care areas include urban areas such as St. Louis). To explore the potential impact of these differences on findings of the main analysis, the

[64] The income cutoff for traditional Medicaid (Title XIX) services for children under the age of six is 133 percent of FPL.

study team conducted a subgroup analysis with the health care utilization measures for the fee-for-service and managed care Medicaid beneficiaries to assess how costs might have differed between them. The findings, presented in Appendix H, did not reveal strong evidence that the associations between WIC participation and health care utilization or diagnosis and treatment of common childhood illnesses in Missouri varied by type of Medicaid enrollment.

Additional robustness checks addressed the fact that, as discussed in Chapter II, the analysis sample for Medicaid costs in Oklahoma was limited to non-Native American children who participate in WIC through the State or one of the seven participating ITOs. The study team compared characteristics of Native Americans and non-Native Americans using data available on the Medicaid eligibility (not claims) files and the birth certificates. Appendix H provides details of these and additional analyses. Given the few significant differences found between the two groups, it is unclear whether one might expect the association between WIC participation and the study outcomes to be larger or smaller if the analysis sample had included Native American children.

## F. Summary and conclusions

The results from the children's analysis indicate that child WIC participation was associated with increased health care utilization. Child WIC participation was associated not only with increased use of preventive care, but also with increased use of other kinds of health care (such as ER visits) and with the increased diagnosis and treatment of common childhood illnesses. Consequently, in both Missouri and Oklahoma, WIC participants incurred higher Medicaid costs for these specific types of services compared with nonparticipants, at least for most children enrolled in fee-for-service Medicaid. Multiple robustness checks were conducted, and the key results can be broadly characterized as demonstrating robustness across plausible alternative methodologies.

Consistent with these findings, total Medicaid costs in Missouri were higher for WIC participants than nonparticipants, on average. Findings for Medicaid costs in Oklahoma differed from the findings for Missouri (and the Buescher study). Total Medicaid costs in Oklahoma were lower for WIC participants than for nonparticipants. Exploratory analyses using disaggregated Medicaid claims data revealed that this apparently anomalous finding was largely due to a small number of nonparticipant children in Oklahoma with high inpatient costs, which drove up the overall average cost for this group (that is, outliers in Medicaid costs had a strong influence on the results). Analysis with quantile treatment effect models and the logarithm of Medicaid costs found that WIC participation was associated with higher Medicaid costs for *most* children in Oklahoma, which is consistent with the findings for Missouri and with the Buescher study.[65]

WM-II replicated the Buescher study with a few key differences. First, the analysis sample used cross-sectional rather than longitudinal data. Second, health outcomes of WIC participants were observed after the revision of the WIC food packages in 2009, although not all children in the WIC participant group received the foods in the revised package only. Third, the methodology improved upon the analytic methods used in the Buescher study by creating

[65] Future research (with much larger data sets) is needed to settle the question of whether child WIC participation was associated with reduced probabilities of higher-cost outlier cases or if this was simply an artifact of the data that does not generalize beyond this group of children in Oklahoma in 2010.

matched comparison groups using IPW rather than using regression models. Despite these differences, WM-II findings were mostly consistent with findings from the Buescher study, and provide additional evidence that child WIC participants are better connected to the health care system than nonparticipants and, consequently, are more likely to use all kinds of health care services and more likely to be diagnosed and treated for common childhood illnesses.[66] The higher prevalence of ER visits among WIC participants might suggest poorer access to appropriate clinic- and office-based care from primary care and other providers. However, some studies have found that interventions designed to increase access to health care services increase both physician office visits and ER visits, suggesting that the two types of services are complimentary (for example, see Finkelstein et al. 2016).

Some caution is warranted in interpreting these results. Selection bias remains a concern. Even after balancing the WIC participants and the matched comparison groups in terms of observable characteristics, it is possible that unobserved differences remained between the two groups. This retrospective observational study does not necessarily demonstrate a causal association between child WIC participation and these outcomes. For example, differences in ER visits might reflect unobserved differences in health care needs rather than the effects of WIC.

Another concern is that most children who participate in WIC entered the program as infants (Castner et al. 2009). Because it is possible for prenatal and infant WIC participation to affect the outcomes in this study (in the same direction), it is likely the analysis did not actually disentangle the associations between *child* WIC participation from *prenatal* and *infant* WIC participation. A related concern is that children who remain on WIC after infancy could systematically differ from those who participated only as infants, leading to selection bias. Without data on mothers' prenatal WIC participation or children's participation in WIC as infants, the study cannot assess these differences.

Finally, it is worth noting that the results are estimates of the associations among child WIC participation and health care utilization, diagnosis and treatment of common childhood illnesses, and Medicaid costs in just one calendar year, as opposed to the entire time children might be enrolled in the Medicaid program. One could hypothesize that increased Medicaid expenditures in the first four years of life among WIC participants might still lead to cost savings in the long run if the underutilization of care in early childhood by non-WIC participants leads to more health problems later in life. WM-II did not collect the data required to examine this hypothesis. Additional research is needed to examine the long-term health and economic benefits of WIC participation.

[66] As Buescher et al. (2003) point out, there is no reason to expect that the incidence of common childhood illnesses would be affected by WIC participation. Thus, the differences between WIC participants and nonparticipants on this outcome raises concerns about undiagnosed and untreated illness among nonparticipant children.

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