Chapter 4

WIC Program

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was established to provide "supplemental nutritious food as an adjunct to good health care during critical times of growth and development, in order to prevent the occurrence of health problems and improve health status..." (P.L. 95-627).[51] The WIC program targets five specific groups: pregnant women, infants, children up to their fifth birthday, breastfeeding women (up to 1 year after an infant's birth), and non-breastfeeding postpartum women (up to 6 months after an infant's birth). In addition to belonging to one of these target groups, WIC participants must be low-income and have one or more documented nutritional risks.

WIC offers a combination of services, including supplemental foods that have been specifically selected to supply nutrients potentially lacking in participants' diets, nutrition education, and referrals to health care and social services. WIC services do not fluctuate by household income. All participants have access to the same basic benefits. The types and amounts of supplemental food provided to each participant are based on participant category, age (for infants), and individual needs and preferences.

WIC is not an entitlement program, so the number of participants served by the program may be affected by Federal funding levels. In FY 2002, WIC served 7.5 million participants per month at an estimated total cost of $4.3 billion (U.S. Department of Agriculture (USDA), Food and Nutrition Service (FNS), 2003a).

Program Overview

A major impetus for the WIC program was the 1969 White House Conference on Food, Nutrition, and Health, which reported nutritional deficiencies among low-income pregnant women and young children. WIC began as a 2-year pilot program in 1972 and was authorized as a permanent program in 1975 (P.L. 94-105). In the intervening years, WIC has grown substantially and has become a key component of the nutrition safety net provided for low-income Americans.

[51]WIC was formerly known as the Special Supplemental Food Program for Women, Infants, and Children. The program name was changed under the Healthy Meals for Healthy Americans Act of 1994 (P.L. 103-448) to emphasize that WIC is a targeted supplemental nutrition program rather than an income supplement program.

Program growth was particularly rapid during the first decade of operation. Between FY 1975 and FY 1985, WIC participation increased from 344,000 participants per month to more than 3.1 million. On average, participation increased about 26 percent per year (USDA/FNS, 2003a). During the next decade, the program continued to grow each year but at a notably slower pace. Total monthly participation increased from about 3.1 million in FY 1985 to 6.9 million in FY 1995. The annual increase during this period averaged about 8 percent. Since the late 1990s, WIC participation has stabilized. Participation actually declined by 1-2 percent in 3 consecutive years between FY 1998 and FY 2000, but has increased modestly (2-3 percent per year) since then.

Much of WIC's growth over the years has been fueled by favorable Congressional funding, which has been influenced at least partially by research suggesting that WIC participation during pregnancy increases infant birthweight and decreases Medicaid costs. In the early- to mid-1990s, program growth was also fueled by infant formula rebate programs, which became mandatory in 1989 (P.L. 101-147). Under the rebate programs, each State awards a competitively bid contract to one infant formula manufacturer. For the exclusive contract on WIC infant formula, manufacturers agree to provide rebates to WIC State agencies for each can of formula purchased by WIC participants. The funds received through the rebate system are used to contain overall costs and to support provision of program benefits to additional participants. In FY 2002, the WIC program recognized $1.5 billion in rebate savings (USDA/FNS, 2003b).

Program Administration

FNS and its seven regional offices provide cash grants to State WIC agencies, issue regulations, and monitor compliance with these regulations. State WIC agencies operate in each of the 50 States, as well as in the District of Columbia, Puerto Rico, Guam, American Samoa, and the American Virgin Islands. Thirty-three Indian Tribal Organizations also serve as State WIC agencies (USDA/FNS, 2003b). State WIC agencies contract with local WIC agencies to provide WIC benefits to participants, monitor compliance with regulations, and provide technical assistance to local agency staff.

Funds allocated to local WIC agencies are used to provide supplemental foods to WIC participants and to pay administrative costs, including the costs of certifying applicants as eligible and providing nutrition education. Each of the roughly 2,200 local WIC agencies operates one or more service delivery sites where participants go to receive WIC services (Bartlett et al., 2002). Most of the local agencies are State, county, or local health departments. Other organizations, however, such as hospitals, State- or locally sponsored maternal and child health programs, and community action agencies, also provide WIC services.

Participant Eligibility

WIC eligibility is based on four factors: State residence, categorical eligibility, income eligibility, and nutritional risk. Unless they are part of a migrant farm worker family, WIC participants must be residents of the State or other jurisdiction (U.S. territory or Indian reservation) supplying the WIC benefits.

Participants must also belong to one of five categorically eligible groups—women during pregnancy and up to 6 weeks after delivery, breastfeeding women (who can participate for up to a year after giving birth), nonbreastfeeding postpartum women (who can participate for up to 6 months after giving birth or other termination of pregnancy), infants (0-12 months), and children up to the age of 5. In April 2002, 50 percent of all WIC participants were children and 26 percent were infants. The remaining 24 percent were women—11 percent pregnant women, 8 percent postpartum nonbreastfeeding women, and 6 percent breastfeeding women (Bartlett et al., 2003; Kresge, 2003).

Income eligibility for the WIC program is defined by each State agency. The cutoff may not be more than 185 percent or less than 100 percent of the Office of Management and Budget's (OMB) poverty income guidelines. As of April 2000, all State agencies used an income eligibility cutoff of 185 percent of poverty (Bartlett et al., 2002). Program regulations allow local WIC agencies to determine that participants are adjunctively income-eligible for WIC if they or certain family members participate in Medicaid, Temporary Assistance for Needy Families (TANF), or the Food Stamp Program (FSP). Since October 1998, applicants not certified under adjunctive income-eligibility provisions must present documentation of income at certification (P.L. 105-336). Before this regulation went into effect, some States allowed applicants to self-report income without documentation.

Since the mid-1980s, several legislative actions have expanded Medicaid income eligibility for pregnant women, infants, and children. As a result, some States have adopted Medicaid income-eligibility limits that exceed the WIC maximum of 185 percent of poverty. In October 2002, 17 States had Medicaid eligibility standards that exceeded the WIC cutoff (National Governor's Association, 2003). In most cases, the expanded income-eligibility cutoff is 200 percent of poverty and is limited to pregnant women and/or infants.

In addition to meeting eligibility requirements associated with residency, participant category, and income, each WIC participant must be at nutritional risk, as documented by a competent professional authority (a physician, nutritionist, nurse, or other health professional). Before 1999, State agencies established their own nutritional risk criteria following broad guidelines in Federal regulations. This autonomy meant that the criteria used to define nutritional risk and, consequently, program eligibility, varied across State agencies. This variability raised concerns about equity. To address these concerns, FNS asked the Institute of Medicine (IOM) to review the scientific basis for the criteria being used to define nutritional risk and to recommend about appropriate criteria for future use (IOM, 1996). The IOM report formed the basis for a standardized list of nutritional risk criteria to be used in all WIC programs nationwide. States are still free to define the specific criteria used to determine program eligibility, but, since April 1999, criteria must be selected from the approved list.

As noted previously, WIC is not an entitlement program. The program must operate within annual funding levels established by Congress. The number of participants served each year depends on available funding and the cost of running the program. To deal with the possibility that local programs may not be able to serve all eligible people, WIC uses a priority system to allocate available caseload slots to eligible applicants. The priority system is designed to ensure that available services go to those most in need. In general, pregnant women, breastfeeding women, and infants are given higher priority than children and nonbreastfeeding postpartum women. In addition, applicants with nutritional risks that are based on hematologic measures, anthropometric measures, or medical conditions are given higher priority than applicants with nutritional risks based on dietary patterns or other characteristics.[52]

[52]See 7 Code of Federal Regulations (CFR), 246.7.

The relative importance of the priority system has declined over time as increasing funds have allowed the program to serve many lower-priority individuals. Between 1988 and 1997, favorable Congressional funding and cost-containment measures (especially formula rebates) fueled an overall increase of 106 percent in WIC participation. Participation increased more substantially for children than for higher-priority groups (128 percent vs. 110 percent for women and 70 percent of infants). The reason for the disparity was that a large percentage of eligible women and infants were already participating because of their higher priority (Oliveira et al., 2002).

Today, the WIC program serves almost half of all infants in the U.S. and about a quarter of the children ages 1-4 years (Hirschman, 2004). The question of how many eligible participants go unserved has been the subject of much debate. Historically, FNS has estimated the number of individuals eligible to participate in WIC in order to predict WIC caseloads. FNS's estimates have been questioned in recent years, however, because estimated coverage rates for some participant categories have exceeded 100 percent. Program advocates argued that FNS underestimates the number of eligible individuals, while others, including members of Congress, raised concerns that the program is serving ineligible individuals. In response to these concerns, FNS completed a number of studies to identify problems with the existing estimation methodology and potential solutions (see, for example, Gordon et al., 1999 and 1997). As a result of these efforts, a new methodology was introduced for estimating the number of WIC eligibles at the State level (Gordon et al., 1999).

Before revising the methodology used at the National level, FNS asked the Committee on National Statistics of the National Research Council to convene a panel of experts to study the existing methodology and make recommendations for improvement. The panel concluded that the existing methodology substantially underestimates the number of individuals eligible to participate in WIC (Ver Ploeg and Betson, 2003). The primary reason for the underestimation is that the methodology does not adequately measure monthly income and adjunctive eligibility. The panel proposed two alternative approaches to estimating WIC eligibility. At the time this report went to press, FNS was in the process of implementing the panel's recommendations.

Program Benefits

WIC was designed to counteract the negative effects of poverty on prenatal and pediatric health (Kresge, 2003). To achieve this goal, the program provides a combination of services, including supplemental foods, nutrition education, and referral to health and social services. Participants are generally certified to receive benefits for 6-month periods and must be recertified to continue receiving benefits. Exceptions to this rule include pregnant women (who are certified for the duration of the pregnancy and up to 6 weeks postpartum), infants (who are generally certified up to 1 year of age), and nonbreastfeeding postpartum women (whose eligibility expires at 6 months postpartum).

Supplemental Foods

The supplemental foods provided by WIC are good sources of many nutrients, including those potentially lacking in the diets of low-income pregnant women and children—protein, iron, calcium, and vitamins A and C. Foods available in WIC food packages include milk, eggs, cheese, dried beans and peas, peanut butter, full-strength (100 percent) fruit or vegetable juices high in vitamin C, and breakfast cereals high in iron and low in sugar. Food packages for infants are limited to iron-fortified infant formula, infant cereals, and, for infants 4 months and older, 100 percent fruit or vegetable juices high in vitamin C. Breastfeeding women whose infants do not receive WIC formula may also receive carrots and canned tuna.

Federal regulations specify minimum nutritional requirements for all WIC foods (USDA/FNS, 2003c). State WIC agencies are not required to authorize every available food that meets minimum nutritional requirements. States may limit authorization to specific brands and types of food based on cost, distribution within the State, participant acceptance, and/or administrative feasibility.

WIC food packages are meant to supplement participants' diets and are not expected to fully satisfy daily nutritional needs. The type and quantity of foods provided to individual participants vary by participant category. Federal regulations define maximum monthly allotments for different types of participants (USDA/FNS, 2003c). Maximum monthly allotments must be made available to participants if medically or nutritionally warranted. However, WIC staff may tailor the content of food packages (within maximum allotments) to meet individual needs and preferences.

Most WIC participants receive vouchers or checks to use in purchasing supplemental foods at authorized retail outlets. In a limited number of geographic areas, foods are delivered to participants' homes or participants pick up foods at warehouses. In recent years, several States have conducted pilot tests on the use of electronic benefits transfer (EBT) systems in disbursing WIC benefits. At least one State has implemented EBT statewide and another State is considering a statewide EBT system.

In mid-2003, FNS launched an initiative to revise existing food packages based on current nutrition recommendations, updated information about the dietary patterns and nutritional needs of low income women, infants and children, and new products in the marketplace (*Federal Register*, 2003). Following a period of public comment, USDA asked the IOM to convene a panel of independent experts to review available science and public comments and to develop recommendations for revising WIC food packages. A preliminary report was released in mid-2004 (IOM, 2004) and the final report is expected in 2005 (Okita, 2004).

Nutrition Education

Because the food package does not meet participants' total nutrient needs, nutrition education is seen as an essential part of the WIC Program. Nutrition education provides a mechanism for teaching WIC participants about recommended eating patterns and for encouraging them to adopt positive food-related attitudes and behaviors. Program regulations define two broad goals for WIC nutrition education:

- To stress the relationship between proper nutrition and good health, with special emphasis on the nutritional needs of the program's target populations.

- To assist individuals at nutritional risk in achieving a positive change in food habits, resulting in improved nutritional status and the prevention of nutrition-related problems (7 CFR, 246.11).

In practice, WIC nutrition education addresses many other topics, such as breastfeeding promotion; the need to avoid cigarettes, alcohol, illicit drugs, and over-the-counter medications during pregnancy; and the importance of childhood immunizations.

State WIC agencies are required to earmark at least one-sixth of annual administrative funds for nutrition education. Local WIC agencies are required to offer all adult participants and caretakers of infant and child participants at least two nutrition education contacts during each certification period. For participants with certifications that extend beyond 6 months, nutrition education must be offered quarterly.

State and local WIC agencies have broad autonomy to develop plans and procedures for providing nutrition education to WIC participants. Consequently, WIC nutrition education is quite diverse and may vary in both quantity and quality from one site to the next. A variety of methods may be used to provide nutrition education. For example, participants may be counseled one-on-one, may attend classes, or may view videos, filmstrips, or slide presentations on a range of nutrition- or health-related topics. Providers are encouraged to ensure that nutrition education messages take into account participants' educational levels, nutritional needs, household situations, and cultural preferences.

Although local WIC agencies are required to offer nutrition education, participants are free to decline these services without affecting receipt of other program benefits. To maximize participation, local agency staff tend to schedule nutrition education activities to coincide with issuance of WIC vouchers (Fox et al., 1998).

Referrals to Health and Social Services

Local WIC agencies are expected to serve as a link between participants and the health care system and to promote routine use of preventive health care services. Local WIC staff are also encouraged to provide referrals, as needed, to appropriate social services, such as the FSP, Medicaid, TANF, and other programs relevant to the participants' needs. The degree to which local WIC agencies actually facilitate linkages to health and social services varies depending on the adequacy of the health and social service infrastructure at the State and local levels and the extent to which participants are already linked into health and social service networks before coming to WIC (Fox et al., 1998).

Research Overview

The WIC program has been studied widely. Indeed, it is the most studied of the Federal FANPs with regard to impacts on nutrition- and health-related outcomes. The available body of research is impressive in size and, in many circles, is seen as solidly convincing that WIC has positive impacts, particularly on birth outcomes. The truth is, however, that much of the available research is clouded by the overarching problem of selection bias. In addition, the complexity of the health outcomes that have been studied has presented unique challenges to WIC researchers, further compromising their ability to obtain clear estimates of program impact.

Over the years, USDA has made a considerable investment in trying to elucidate the impact of WIC on participants' nutrition and health status. The first national evaluation of WIC was completed when the program was still very young (Edozien et al., 1979). The so-called Medical Evaluation of WIC included more than 50,000 WIC participants in 14 States and examined impacts on birth outcomes, child growth, anemia, and other measures of nutritional status. Study authors reported positive impacts, but the study has been widely criticized for, among other things, poor response rates on followup measures and dissimilarities between participant and nonparticipant groups. In addition, the study's dose-response design, which compared newly enrolling participants (nonparticipants) with participants who had been in the program for some time (participants), has come to be regarded as a poor design for studying birth outcomes.

In the early 1980s, USDA sponsored the National WIC Evaluation (NWE) (Rush et al.,1986) which consisted of four substudies, including an historical study of birth outcomes (Rush et al.,1988a); a longitudinal study of pregnant women (Rush et al.,1988d); a cross-sectional study of infants and children (Rush et al., 1988c); and a study of food expenditures (Rush et al.,1988b). Although the NWE is generally regarded as a carefully implemented study and remains the largest and most comprehensive study of WIC ever completed, it also had problems with noncomparability between participant and nonparticipant groups, as well as with crossovers between groups.

In the late 1980s, USDA undertook a feasibility assessment and design effort aimed at developing and fielding a study that would produce reliable estimates of the impact of WIC on infants and children. Outcomes to be examined included dietary intake, anemia, physical and cognitive growth, and use of health care services. Unfortunately, the so-called WIC Child Impact Study was canceled in 1992, at the request of Congress, before the full evaluation could be fielded. Results from a limited field test provide some information about potential impacts on young infants (6 months old) but fall far short of providing valid impact estimates (Burstein et al.,1991). In addition, the field test suffered from some of the same problems with noncomparability and crossovers that affected the NWE.

USDA's most recent efforts to assess WIC impacts have relied on secondary analyses of extant databases, most notably the 1988 National Maternal and Infant Health Survey (NMIHS) (Gordon and Nelson, 1995) and a specially created WIC-Medicaid database that included data on Medicaid expenditures, maternal WIC participation during pregnancy, and birth outcomes for live births in five States in 1987-88 (Devaney et al., 1990/91; Devaney, 1992; Devaney and Schirm, 1993). These secondary analyses have focused almost exclusively on impacts on birth outcomes, including savings in Medicaid costs.

In addition to USDA-sponsored research, many independent researchers have looked at WIC impacts using secondary analyses of existing databases, as well as primary data collected on State or local samples. The remainder of this chapter summarizes findings from all of this research.

The discussion is organized around WIC participant categories. Impacts of prenatal WIC participation are discussed first. The bulk of this research focuses on impacts on birth outcomes, with a much smaller body of work examining impacts on pregnant women themselves. Research that examined the impact of WIC participation on the initiation and/or duration of breastfeeding is also included in this section. The rationale is that the decision to initiate breastfeeding is generally made before an infant leaves the hospital, making the prenatal period a key point for intervention. Although decisions about breastfeeding duration are generally made during the postpartum period, for ease of discussion, all research related to breastfeeding outcomes are discussed in the same section.

The second section summarizes research that assessed impacts of WIC participation on infants and children. The third section describes studies that have assessed impacts on postpartum women (both nonbreastfeeding and breastfeeding). The final section summarizes findings from four studies that examined impacts on all types of WIC participants, without differentiating participant groups, or on household-level outcomes.

Selection Bias

Because use of randomized experiments is considered unethical by many policymakers and program administrators, only one study (Metcoff et al., 1985) used random assignment to study the impact of the WIC program (see chapter 2 for an explanation of the randomized experiment). Random assignment was feasible for these authors because, at the time the study was conducted, the demand for WIC participation at the study site exceeded the available funding. All other studies of WIC impacts have used quasi-experimental designs.

Selection bias, as discussed in chapter 2, is driven by the fact that women who participate in WIC or who enroll their infants or children in WIC may differ in unmeasured ways from women who are eligible but do not participate. These differences may influence the outcomes being studied. This influence could run in either direction, resulting in overestimation or underestimation of the true effect of the program. For example, women who participate in WIC or enroll their children in WIC may be more health-conscious and motivated than women who do not participate, or may be more knowledgeable about and connected to the health care system. These women and their offspring might have better outcomes than nonparticipants, even in the absence of the program. In this case, estimates of WIC impacts would be overstated. On the other hand, because the WIC program specifically targets individuals who are at nutritional risk, WIC participants may be more likely, *a priori*, to have poor outcomes than otherwise comparable individuals who do not enroll in the program. In this case, estimates of WIC impacts would be understated.

The problem of selection bias was largely ignored in the earliest WIC research. The first study to attempt to control from selection bias was the WIC-Medicaid Study, which estimated the impact of prenatal WIC participation on a number of birth outcomes (Devaney et al. (1990/91)). Study authors estimated a number of different selection-bias-adjustment models but ultimately rejected all of them because they produced implausible findings and were extremely sensitive to minor changes in specification and to estimation procedures. Devaney and Schirm (1993) reported comparable experiences in a subsequent analysis of the same dataset. Researchers attributed the problems encountered in attempting to control for selection bias to the limited number of variables available in the administrative (Medicaid and WIC) and birth certificate data included in the WIC-Medicaid database.

Gordon and Nelson (1995) used the NMIHS, a nationally representative dataset that includes information on the characteristics of women who gave birth in 1988 and their offspring, to study the effects of WIC. With access to a much richer data set, Gordon and Nelson were able to control for many more covariates in their basic model, including income and use of cigarettes, alcohol, marijuana, and cocaine. They also had more options for variables (instruments) to include in selection-bias-adjustment models. They estimated several models of the effect of WIC on birthweight, using various combinations of the following variables: per capita State-level WIC food expenditures (a proxy for the availability of WIC services); an indicator of whether the family had income from wages (as an indicator of the level of contact with public assistance agencies); and an indicator of WIC participation during previous pregnancies.

Ultimately, Gordon and Nelson deemed their efforts to control for selection bias to be unsuccessful. After several different estimation procedures and model specifications yielded implausible and highly unstable results, they concluded the following:

> It is possible that the selection-bias-correction models of the effects of WIC on birth outcomes produce unstable and implausible results because the factors affecting WIC participation and birthweight are very nearly identical, since WIC targets low-income women at risk for poor pregnancy outcomes. In this case, modeling the participation decision is not likely to be a useful approach to controlling for selection bias.

Brien and Swann (1999) analyzed data from the NMIHS with the explicit goal of developing strategies to deal with selection bias. To minimize potential bias, they restricted their sample to non-Hispanic Blacks and non-Hispanic Whites and carried out separate analyses for each group. The authors used a two-stage estimation procedure, similar to the basic approach used by Gordon and Nelson (1995). To model the participation decision, the authors used a variety of State-level characteristics that served as proxies for the availability and “generosity” of WIC and other welfare programs. These characteristics included relative ease of the State’s WIC income certification policies, presence of brand-name purchase restrictions for WIC foods, presence of adjunctive income eligibility for AFDC participants, value of the first trimester hemoglobin level used to define nutritional risk, number of WIC clinics per 1,000 low-income persons, number of WIC clinics per 100 square miles, AFDC guarantee for a family of four, and average Medicaid expenditure for a family of four.

Like previous researchers, Brien and Swan estimated several models with different combinations of instruments. They, too, found that results were very sensitive to model specification. In some cases, results showed a negative association between WIC participation and birth outcomes, although the differences were not statistically significant. Moreover, the sensitivity to model specification varied substantially by race, suggesting that the instruments used did a better job of predicting WIC participation among Blacks than among Whites.

Brien and Swan also estimated a fixed-effects model, using a sample of women who had at least one birth before the 1988 NMIHS birth. This approach assumes that critical unmeasured differences between WIC participants and non-WIC participants are mother-specific and do not vary over time. The analysis examined whether differences in WIC participation status for the two births affected outcomes.[53] The fixed-effects model yielded results that were generally smaller in magnitude and stronger in statistical significance than the two-stage model. For Whites, findings for the incidence of low birthweight were completely different (a negative but statistically insignificant effect) than findings for the two-stage model.

As the preceding discussion illustrates, the problem of selection bias has proven especially thorny in research on birth outcomes. Some researchers who have investigated WIC impacts on other outcomes or for other WIC participant groups have reported success in controlling for selection bias. This has not been a universal experience, however, and many of these researchers have also struggled with limited candidates for identifying variables and with models that produce inconsistent, implausible, or unstable results.

Impacts of WIC Prenatal Participation

The prenatal component of the WIC program is, by far, the most studied part of the program. The vast majority of the research in this area focuses on impacts on birth outcomes. Substantially less research has been done on the impact of prenatal WIC participation on the initiation of breastfeeding. Even less research has examined the impact of prenatal WIC participation on the women themselves (for example, on women's dietary intake and/or nutritional status). A small number of studies have examined the relationship between prenatal WIC participation and child development outcomes. Because several of these studies look at WIC participation during infancy or childhood, in addition to prenatally, these studies are discussed later in this chapter-in the section that deals with impacts on infants and children.

Birth Outcomes: Research Overview

The literature search identified 38 studies that examined impacts of prenatal WIC participation on a variety of birth outcomes.[54] The outcomes most frequently studied were mean birthweight and likelihood of low birthweight (defined as an infant weighing less than 2,500 gm, or 5.5 pounds (lb)). Other birth outcomes included mean gestational age (length of gestation at time of delivery), and likelihood of very low birthweight (less than 1,500 gm, or 3.3 lb), premature birth (generally defined as birth before 37 weeks gestation), intrauterine growth retardation (IUGR) or being small-for-gestational age, neonatal mortality, and infant mortality. Several studies also examined the impact of prenatal WIC participation on Medicaid costs associated with delivery and newborn care (up to 30-60 days after birth).

Selected characteristics of these studies are summarized in table 17. The 38 identified studies can be divided into four groups based on scope/generalizability and general methodology. The two national USDA-sponsored WIC evaluations, although substantially different in design, make up Group I. The strongest of the two, the NWE, includes two different components—the Longitudinal Study of Pregnant Women (Rush et al., 1988d) and the Historical Study of Pregnancy Outcomes (Rush et al., 1988a). Although the NWE is the most recent national evaluation of the WIC program, it is based on data collected in 1982 and 1983 (Rush et al. 1988d) and historical data from the mid-70s through 1980 (Rush 1988a), and is therefore quite dated.

Group II includes nine studies that used national survey data, almost always the NMIHS, to examine WIC impacts on birth outcomes. Although some of the research that used the NMIHS was completed recently, all of it is based on births in 1988. One study in this group (Kowaleski-Jones and Duncan, 2002) used data from the 1990-96 waves of the National Longitudinal Survey of Youth (NLSY).

Group III, the largest group, includes 15 studies that linked State-level files of WIC participant information with other State-level files, generally vital statistics

[53]The assumption that key unmeasured maternal characteristics do not vary over time is a generous one. There is no guarantee that maternal effects on a pregnancy—for example, the mother's general health, use of cigarettes and alcohol, weight gain, and diet—are constant over time, and the NMIHS had relatively limited information on characteristics associated with earlier pregnancies. Moreover, there is no guarantee that women who had two births are representative of all prenatal WIC participants (Besharov and Germanis, 2001).

[54]Several very early unpublished papers and reports included in a review prepared by Rush and colleagues (1986) for the NWE are not included because they could not be located. Given the age of the data and the descriptions included in Rush's summary, it is doubtful that these documents would add anything to the present discussion. Most, if not all, of these studies appear to have centered on cross-tabulations that were subjected to few, if any, statistical controls.

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Group I: National evaluations						
Rush et al. (1988a) (NWE)	Birthweight, gestational age, likelihood of low birthweight, very low birthweight, and premature birth, and neonatal and infant mortality rates	Vital statistics records for 1,392 counties in 19 States and DC (1972-80)	N/A (Aggregate data analysis)	Trends analysis relating WIC program penetration over time to birth outcomes	WIC penetration index	Multivariate regression
Rush et al. (1988d) (NWE)	Birthweight, gestational age, likelihood of premature birth, and fetal mortality rate	Record abstractions in 174 WIC sites and 55 prenatal clinics(1983-84)	Nationally representative sample of pregnant WIC participants and income-eligible nonparticipants receiving prenatal care in surrounding public health clinics or hospitals (n=3,935)[3]	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Edozien et al. (1979)	Birthweight, gestational age	Primary data collection in 19 WIC sites in 14 States. Data were collected at time of WIC enrollment, approximately every 3 months until delivery, and once after delivery (1973-76)	Postpartum WIC participants who participated prenatally (n~1,000)	Participants, before vs. after, separate groups	Newly enrolling participants vs. participants with varying lengths of participation	Multivariate regression
Group II: Secondary analysis of national surveys						
Finch (2003)	Likelihood of low birthweight	1988 NMIHS	WIC and non-WIC women who were White, Black, or Hispanic with live singleton births that were at least 22 weeks gestation (n=12,814)	Participant vs. nonparticipant	Participation dummy with short- (<6 months) and long-term (6+ months) WIC participation	Multivariate regression

See notes at end of table.

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Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Kowaleski-Jones and Duncan (2002)	Birthweight	1990-96 NLSY	(1) NLSY children born between 1990 and 1996 (n=1,984) (2) NLSY children born between 1990 and 1996, with at least 1 other sibling born during the same period (n=453 sibling pairs)	Participant vs. nonparticipant	Participation dummy	(1) Multivariate regression (2) Fixed-effects model
Hogan and Park (2000)	Likelihood of low birthweight and very low birthweight	1988 NMIHS	WIC and non-WIC women (n=8,145)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Brien and Swann (1999)	Birthweight, likelihood of low birthweight and premature birth, and neonatal and infant mortality rates	1988 NMIHS	(1) WIC and income-eligible non-Hispanic women who were at nutritional risk (n=7,778) (2) WIC and income-eligible non-Hispanic women with at least 1 live birth prior to 1988 (n=6,254 pairs of births)	Participant vs. nonparticipant	(1) Participation dummies: 1 for ever participated and 1 for participated during first trimester (2) Participation status for each pregnancy	(1) Multivariate regression, including attempt to control for simultaneity and several selection-bias-adjustment models (2) Fixed-effects model; separate models estimated for Blacks and Whites
Moss and Carver (1998)	Neonatal mortality rate	1988 NMIHS	WIC and income-eligible non-Hispanic women (n=7,796)	Participant vs. nonparticipant	Participation dummy with and without Medicaid	Logit analysis
Frisbie et al. (1997)	Likelihood of intrauterine growth retardation, premature birth, and heavy preemie[4]	1988 NMIHS	WIC and non-WIC women (n=8,424)	Participant vs. nonparticipants	Participation dummy	Multivariate regression analysis to identify determinants of birth outcomes

See notes at end of table.

Continued—

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Covington (1995)	Likelihood of low birthweight and very low birthweight	1988 NMIHS	WIC and non-WIC African American women who received some prenatal care (n=3,905)	Participant vs. nonparticipant	Participation dummy	Multivariate regression. Separate models for LBW vs. normal weight and VLBW vs. normal weight for each of 4 subgroups based on combinations of income and receipt of Medicaid and/or AFDC
Gordon and Nelson (1995)	Birthweight, gestational age, likelihood of low birthweight, very low birthweight, and premature birth, and neonatal and infant mortality rates	1988 NMIHS	WIC and income-eligible women (n=6,170)	Participant vs. nonparticipant	Participation dummy	Multivariate regression and logit analysis. Birthweight analysis included separate models for Blacks and Whites, as well as several alternative models to control for simultaneity.[5, 6] Attempted, but rejected, selection-bias adjustment.
Joyce et al. (1988)	Neonatal mortality rate	1977 Census data for large counties in the U.S.	Data for 677 counties with 50,000+ residents for White analysis and 357 counties with 5,000+ Blacks for Black analysis	Cost-effectiveness study using aggregate data	State-specific number of pregnant women enrolled in WIC per 1,000 State-specific eligible women	Multivariate regression, including selection-bias adjustment. Separate models for Blacks and Whites.
Group III: State-level studies using WIC participation files matched with Medicaid and/or birth record files						
Roth et al. (2004)	Likelihood of low birthweight, very low birthweight, neonatal mortality, postneonatal mortality, infant mortality[7]	Linked WIC, Medicaid, and vital statistics records for births in Florida between January 1996 and the end of December 2000	WIC and non-WIC Medicaid recipients who did not participate in high-risk obstetrical program (n=295,599)	Participant vs. nonparticipant	Participation dummy	Multivariate regression

See notes at end of table.

Continued—

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Gregory and deJesus (2003)	Likelihood of low birthweight, very low birthweight, neonatal mortality, and infant mortality, length of infants' hospital stay, Medicaid costs	Linked WIC, Medicaid, birth and death record, and hospital discharge files for births in New Jersey between May 1992 and December 1993	WIC and non-WIC Medicaid recipients with live singleton births (n=19,614)	Participant vs. nonparticipant	Participation dummy	Multivariate regression. Separate models for Blacks and non-Blacks
Buescher and Horton (2000)	Birthweight, likelihood of low birthweight and very low birthweight, Medicaid costs	Linked WIC, Medicaid, and birth record files for 1997 births in North Carolina	WIC and non-WIC Medicaid recipients who were enrolled in prenatal care and had live singleton births (n=42,965)	Participant vs. nonparticipant	Participation dummy	Multivariate regression, including several alternative models to control for simultaneity[8]
Ahluwalia et al. (1998)	Likelihood of low birthweight	Linked WIC and birth record files for 1992 births in Michigan	WIC and non-WIC women with full-term births (n=53,782)	Participant vs. nonparticipant	Dose response: Length of prenatal WIC "exposure"[9]	Multivariate regression
Buescher et al. (1993)	Likelihood of low birthweight and very low birthweight, Medicaid costs	Linked WIC, Medicaid, and birth record files for 1988 births in North Carolina	WIC and non-WIC Medicaid recipients who were enrolled in prenatal care (n=21,900)	Participant vs. nonparticipant	Participation dummy and dose-response: Percentage of gestation on WIC	Multivariate regression, including attempt to control for simultaneity[10]
Devaney and Schirm (1993)	Likelihood of neonatal and infant mortality	FNS WIC/Medicaid (1987-88)	WIC and non-WIC Medicaid recipients (n=111,958)	Participant vs. nonparticipant	Participation dummy: Enrolled by 30 weeks gestation	Probit analysis
Devaney (1992)	Likelihood of very low birthweight	FNS WIC/Medicaid (1987-88)	WIC and non-WIC Medicaid recipients (n=111,958)	Participant vs. nonparticipant	Participation dummy	Probit analysis, including attempts to control for simultaneity[11]
Devaney et al. (1990/91)	Birthweight, gestational age, likelihood of premature birth, and Medicaid costs	FNS WIC/Medicaid (1987-88)	WIC and non-WIC Medicaid recipients (n=111,958)	Participant vs. nonparticipant	Participation dummy	Multivariate regression and probit analysis, including attempt to control for simultaneity.[12] Attempted but rejected selection-bias adjustment.

See notes at end of table.

Continued—

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
New York State (1990)	Birthweight, gestational age, likelihood of low birthweight, very low birthweight, and premature birth, and Medicaid costs	Linked WIC, birth record, and hospital discharge files for births in New York State in the last 6 months of 1988	Singleton births to WIC and non-WIC women (n=132,994)	Participant vs. nonparticipant within 3 groups defined on the basis of insurance coverage (Medicaid, private, none)	Participation dummy	Multivariate regression
Simpson (1988)	Likelihood of low birthweight	Aggregate county-level data for North Carolina, including vital statistics, demographic and service infrastructure characteristics, and program penetration and expenditures (1980-85)	Data for 75 (of 100) counties, all of which provided WIC and other prenatal care services for all county residents (rather than sharing responsibility with another county)	Trends analysis relating WIC penetration over time to birth outcomes	Program "intensity" variable based on county-level WIC expenditures	Multivariate regression
Stockbauer (1987)	Birthweight, gestational age, likelihood of low birthweight, very low birthweight, premature birth, small-for-gestational-age, and neonatal mortality	Linked WIC, birth and death record files for 1982 births in Missouri	Matched WIC and non-WIC women with singleton births (n=9,411 pairs)[13]	Participant vs. matched control	Participation dummy and dose response: Dollar value of redeemed vouchers	Analysis of covariance
Schramm (1986)	Birthweight, likelihood of low birthweight, neonatal mortality rate, and Medicaid costs	Linked WIC, Medicaid, birth record, hospital care, and death record files for 1982 births in Missouri	WIC and non-WIC Medicaid recipients (n=8,546)	Participant vs. nonparticipant	Participation dummy and dose response: WIC food costs adjusted for length of pregnancy	Multivariate regression

See notes at end of table.

Continued—

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Stockbauer (1986)	Birthweight, gestational age, likelihood of low birthweight, and neonatal mortality rate	Linked WIC, birth, and death record files for 1980 births in Missouri	WIC and non-WIC Missouri residents with singleton births (n=6,732 WIC; sample for non-WIC not reported)	Participants vs. 3 different nonparticipant groups: (1) all non-WIC births; (2) random sample of non-WIC births; (3) matched group of non-WIC births[14]	Participation dummy and dose-response: Duration of participation and dollar value of redeemed WIC coupons	Analysis of covariance. Separate analyses for White, non-White, and total group.
Schramm (1985)	Birthweight, likelihood of low birthweight, Medicaid costs	Linked WIC, Medicaid, birth, and hospital care records for 1980 births in Missouri	WIC and non-WIC Medicaid recipients (n=7,628)	Participant vs. nonparticipant	Participation dummy and dose response: WIC food costs adjusted for length of pregnancy	Analysis of covariance
Kotelchuck, et al. (1984)	Birthweight, gestational age, likelihood of low birthweight, premature birth, small-for-gestational-age birth, and neonatal mortality rate	Linked WIC, birth, and death records for 1978 births in Massachusetts	Matched WIC and non-WIC women with singleton births (n=4,126 pairs)[15]	Participant vs. matched control	Participation dummy and dose response: Months on WIC and percent of pregnancy on WIC	Bivariate comparisons
Group IV: Other State and local studies						
Reichman and Teitler (2003)	Birthweight, likelihood of low birthweight	Standardized data collected for women enrolled in New Jersey's HealthStart program for pregnant Medicaid recipients between 1988 and 1996	All WIC and non-WIC HealthStart participants who had a live singleton birth (n=90,117)	Participant vs. nonparticipant	Participation dummy	Multivariate regression, including attempt to control for simultaneity[16]
Brown et al. (1996)	Birthweight, likelihood of low birthweight, and infant mortality rate	Medical records, birth, and death certificates for births in 1 Indiana hospital between January 1988 and June 1989	Non-Hispanic women who delivered at the area's primary hospital for the "underserved" (n=4,707)	Participant vs. nonparticipant	Participation dummy	Multivariate regression

See notes at end of table.

Continued—

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Mays-Scott (1991)	Birthweight	WIC records in 1 county health department in Texas (1987-89)	Prenatal WIC participants who were $\leq$17 years and had at least 1 previous pregnancy (n=217)	Participants, before vs. after	Dose response: Number of months enrolled, nutrition education contacts, and voucher pickups	Analysis of variance
Collins et al. (1985)	Birthweight	Primary data collection in public health department clinics in 6 Alabama counties (1980-81)	WIC and non-WIC pregnant women (n=519)	Participant vs. nonparticipant	Participation dummy	Bivariate t-tests
Metcoff et al. (1985)	Birthweight	Primary data collection at a prenatal clinic in 1 hospital in Oklahoma (1983-84)	Income-eligible pregnant women selected at mid-pregnancy based on predicted birthweight; roughly equivalent numbers were predicted to have average-size babies vs. small or large babies (n=410)	Randomized experiment	Participation dummy	Multivariate regression
Heimendinger et al. (1984)	Birthweight	WIC and medical records in 3 WIC clinics and 4 non-WIC clinics in the same Boston neighborhoods (1979-81)	WIC and Medicaid-eligible infants and toddlers up to 20 months of age with at least 2 height and weight measurements[17] (n=1,907)	Participant vs. nonparticipant	Participation dummy based on mother's participation in WIC during pregnancy	Multivariate regression

See notes at end of table.

Continued—

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Kennedy and Kotelchuck (1984)	Birthweight, gestational age, likelihood of low birthweight and small-for-gestational-age birth, and fetal death rate	WIC and medical records in WIC sites and non-WIC health facilities in 4 geographic areas of Massachusetts (1973-78) (Reanalysis of data from Kennedy et al., 1982)	Matched WIC and non-WIC pairs of pregnant women (n=418 pairs)[18, 19]	Participant vs. matched control	Participation dummy and dose response: Number of months vouchers received	Bivariate comparisons
Bailey et al. (1983)	Birthweight	Primary data collection at 1 WIC site and 1 non-WIC site in Florida (Dates not reported)	WIC and income-eligible nonparticipants who were 30 weeks pregnant at time of recruitment and receiving identical prenatal care (n=101)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Paige (1983)	Medicaid costs, health care utilization	Medicaid records in 4 counties in Maryland, 2 in which WIC was available and 2 in which WIC was not available (1979-80)	WIC and income-eligible non-WIC women who were on Medicaid for at least 16 weeks during pregnancy (n=114)	Participant vs. nonparticipant	N/A	Comparisons of means and proportions (no statistical tests reported)
Kennedy, et al. (1982)	Birthweight, likelihood of low birthweight	WIC and medical records in WIC sites and non-WIC health facilities in 4 geographic areas of Massachusetts (1973-78)	WIC and WIC-eligible women (n=1,297)[18]	Participant vs. nonparticipant	Participation dummy and dose response: Number of vouchers received, months on WIC	Multivariate regression

See notes at end of table.

Continued—

Table 17—Studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Silverman (1982)	Birthweight, likelihood of low birthweight	Medical records for random sample of women enrolled in Maternity and Infant Care Project (MIC) in Allegheny County, PA, before (1971-74) and after (1974-77) initiation of WIC	WIC and income-eligible nonparticipants (n=2,514)	Participants, before vs. after, separate groups	Participation dummy	Multivariate regression

Notes: N/A = Not applicable.

[1] Data sources:

FNS WIC/Medicaid = FNS' WIC/Medicaid database.

NLSY = National Longitudinal Survey of Youth.

NMIHS = National Maternal and Infant Health Survey.

[2] Unless the description of the study sample indicates that a comparison group was limited to nonparticipants who were income-eligible for WIC or known to be Medicaid participants, all income levels were included in the comparison group. Income was generally controlled for in the analysis if the information was available.

[3] Maximum analysis sample; sample varies by outcome. Birth outcome data were available for only about 75 percent of women in the study.

[4] Intrauterine growth retardation defined as fetal growth ratio of less than 85 percent (observed birthweight at gestational age by mean for gestational age of sex-specific fetal growth distribution). Heavy preemie defined as birthweight of 2,500 gm or more and gestation of less than 37 weeks. (Authors report that mortality rate for heavy preemies may be twice that of normal birthweight infants).

[5] Used three alternative definitions of WIC participation to control for simultaneity in analyses of impacts on birthweight and gestational age: (1) during first 8 months; (2) during first 7 months; (3) during first 6 months. Also estimated model for birthweight that controlled for gestational age.

[6] For all outcomes, estimated basic model as well as separate models for four different cohorts defined by length of gestation thresholds: 28 weeks, 32 weeks, 36 weeks, and 40 weeks.

[7] Authors also examined impacts on birth defects, C-section, and complications during pregnancy and delivery. No significant differences were noted for birth defects or complications during pregnancy and delivery. The rate of C-section was significantly greater for WIC participants.

[8] Alternative models included (1) women who enrolled in WIC after 33 weeks gestation included in the nonparticipant group, (2) three separate cohorts, based on gestational age (29, 33, and 37 weeks), and (3) gestational age as a control variable.

[9] Exposure for women who did participate in WIC was considered high = enrolled before 12 weeks gestation, medium = enrolled at 12-20 weeks gestation, and low = enrolled at 21-37 weeks gestation.

[10] In addition to basic model, estimated alternative model that included women who enrolled in WIC at 36 weeks gestation or later in the nonparticipant group.

[11] Alternative models defined WIC participants as those who enrolled in WIC (1) before 32 weeks gestation and (2) by 30 weeks gestation.

[12] Estimated two alternative models: (1) basic model with addition of control for first-trimester WIC participation and gestational age, (2) basic model with WIC participants who enrolled after 36 weeks considered nonparticipants.

[13] Pairs matched on age, race, education, gravidity, number of births this pregnancy, and marital status.

[14] Pairs matched on age, race, education, number births this pregnancy, smoking during pregnancy, and pre-pregnancy weight.

[15] Pairs matched within catchment area on age, race, parity, education, and marital status.

[16] Included separate model to control for gestational-age bias, but sample was restricted based on initiation of prenatal care (1st or 2nd trimester) rather than timing of WIC enrollment.

[17] The main focus of study was impact of WIC on children's growth; however, the authors compared birthweights of subjects whose mothers were and were not in WIC.

[18] WIC-eligible women included in the nonparticipant group were wait-listed for WIC during their pregnancy, enrolled in WIC postpartum, or women who received prenatal care at non-WIC health care facilities in same neighborhood but never enrolled in WIC.

[19] Approximately 80 percent of women were matched on race, age, parity, marital status, and income. The remainder were matched on four of the five variables.

files and Medicaid files, to study birth outcomes among WIC participants and nonparticipants. With three exceptions (Devaney et al., 1990/91; Devaney, 1992; Devaney and Schirm, 1993), all of the studies in Group III are based on data from one State. The three excepted studies used the FNS WIC-Medicaid database. This database was assembled by FNS to address a congressional mandate to determine "savings in Medicaid costs for newborns and their mothers during the first 60 days after birth from participating in the WIC program during pregnancy" (Devaney et al., 1990). A secondary objective for the database was to examine effects of participation on birthweight and gestational age. The FNS WIC-Medicaid database includes WIC participation, birth certificate, and Medicaid claims data for five States (Florida, Minnesota, North Carolina, South Carolina, and Texas). For the first four States, the database includes data for all births in 1987. For Texas, the database includes data for all births during the first 6 months of 1988.

Most of the research in Group III is based on data collected in the 1980s. However, four studies are based on more recent data. Roth et al. (2004) analyzed data for Medicaid births in Florida from 1996-2000;[55] Gregory and deJesus (2003) analyzed births in New Jersey for an 18-month period in 1992-93; Buescher and Horton (2000) used 1997 data from North Carolina (this study is an update of a previous study conducted in 1988 (Buescher et al., 1993)); and Ahluwalia et al. (1998) used data for 1992 births in Michigan.

Finally, Group IV includes 11 State or local studies that examined WIC impacts among pregnant women receiving care in particular programs, hospitals, or clinics. All but one of these studies (Reichman and Teitler, 2003) used data that were collected in the 1970s and 1980s. Reichman and Teitler used data that were collected between 1988 and 1996.

Methodological Considerations

Before reviewing findings from the studies presented in table 17, it is important to understand three methodological considerations that, in addition to selection bias, affect interpretation of research on birth outcomes: simultaneity of WIC participation and gestational age, influence of the comparison group used, and use and adequacy of prenatal care.

Simultaneity of WIC Participation and Gestational Age. Women who deliver early have less chance of enrolling in WIC. Women who go to term have a greater chance of enrolling. Consequently, both the decision to participate in WIC and the length of WIC participation are inexorably linked with gestational age, an important predictor of most birth outcomes. This simultaneity means that assessments of WIC impact that rely solely on a binary indicator of participation are likely to *overstate* the impact of the program. Moreover, because the duration of WIC participation is also simultaneous with gestational age, a traditional dose-response approach—estimating WIC impacts based on number of months of WIC participation—although employed in several studies summarized in table 17, is not a satisfactory solution to the problem.

Gordon and Nelson (1995) studied several approaches to addressing the relationship between the timing of WIC enrollment and gestational age (pregnancy duration). These included omitting very late enrollees (enrolled after the eighth month) from the WIC group, including gestational age as an independent variable in the regression, and defining several cohorts of WIC participants based on gestational age (pregnancy duration) at the time of WIC enrollment. All of these approaches decreased estimated impacts to varying degrees. Gordon and Nelson ultimately concluded that each of the approaches to controlling for simultaneity systematically underestimated the impact of WIC because they effectively eliminated any effect WIC might have on extending gestation. The authors suggested that results from analyses using a binary indicator of WIC participation (participant vs. nonparticipant) and those comparing various cohorts of WIC participants (in an effort to control for simultaneity) probably bound the magnitude of the true effect.

Influence of the Comparison Group Used. Research has consistently shown that specific types of women are more likely than other women to participate in WIC. Characteristics associated with increased likelihood of WIC participation include younger age, lower income, lower educational levels, being unmarried, and being African American. Several early studies of the impact of WIC on birth outcomes attempted to control for these differences by creating matched pairs of participants and nonparticipants (Kennedy and Kotelchuck, 1984; Kotelchuck et al., 1984;

[55]This study was first presented in 2000, with a subset of the data (Roth et al., 2000). Just before this report went to press, the author provided an update that includes data for the full 5-year period (1996-2000) (Roth et al., 2004). A manuscript is currently in preparation.

Stockbauer, 1987). Matching was limited, however, to variables that were available on birth certificates, most often maternal age, race, parity, education, and marital status. Researchers were unable to control for other important variables, particularly income and key characteristics related to pregnancy, and generally did not do so in their analyses (for example, analyses for Kennedy and Kotelchuck (1984) and Kotelchuck (1984) were limited to chi-squares and t-tests). Thus, the comparability of treatment and comparison groups in these studies is still open to question, despite the fact that the groups were "matched."

In interpreting findings from these studies, it is important to realize that, to the extent that comparison-group women were higher income or less at-risk than WIC women, the true impact of the WIC program (at the time these studies were conducted) may have been *underestimated*.

In 1985, Schramm studied the impact of WIC on Medicaid costs for newborns in Missouri. By limiting the analysis to Medicaid recipients, all of whom were income-eligible for WIC, Schramm created a ready-made comparison group and minimized (but did not eliminate) the potential influence of noncomparable incomes. The approach used by Schramm has been adapted and used by many other researchers, most notably in the USDA-sponsored WIC-Medicaid studies (Devaney et al., 1990/91; Devaney, 1992; Devaney and Schirm, 1993) (see Group III in table 17). In interpreting results of these Medicaid-based studies, it is important to recognize that they are limited to the lowest income WIC participants. At the time these studies were conducted, WIC eligibility was defined as 185 percent of poverty, while Medicaid eligibility was generally set at 130 percent of poverty or lower. Because lower income women are at higher risk of poor birth outcomes, these studies probably *overstated* the impact of WIC.

Use and Adequacy of Prenatal Care. Receiving adequate prenatal care is expected to independently affect most birth outcomes. Consequently, most recent research has controlled for the adequacy of prenatal care in order to estimate the independent effect of WIC—that is, the impact of WIC *over and above* the impact of receiving adequate prenatal care. However, because encouraging prenatal care and potentially providing a link to such care is a major focus of the WIC program, including adequacy of prenatal care as a covariate effectively *understates* the full impact of the WIC program. Moreover, Currie (1995) argues that including prenatal care in multivariate models may be inappropriate because prenatal care and WIC participation may be simultaneously chosen.[56]

Birth Outcomes: Research Results

Table 18 summarizes findings from the available research by outcome. Results for each study are reported using the primary author's name. In the interest of providing a comprehensive picture of the body of research, both significant and nonsignificant results are reported in table 18 and in all other "findings" tables included in this report. As noted in chapter 1, a consistent pattern of nonsignificant findings may indicate a true underlying effect, even though no single study's results would be interpreted in that way. Readers are cautioned, however, to avoid the practice of "vote counting" or adding up all the studies with particular results. Because of differences in research design and other considerations, as discussed in the text, findings from some studies merit more consideration than others.

For the first two outcomes in the table (mean birthweight and mean gestational age), a *higher* value is associated with a positive WIC impact. For the remaining outcomes (for example, the likelihood of low birthweight), a *lower* value is associated with a positive WIC impact. The column headings in table 18 vary accordingly, so that significant *positive* WIC effects are always shown in the far left column of the table.

As noted in the preceding discussion, all of the available studies have limitations that require that their findings be caveated. Thus, no single study provides a definitive answer on WIC's effectiveness, but the body of research provides suggestive evidence. As table 18 illustrates clearly, the majority of studies reported positive differences that favor WIC participants. In most cases, differences were statistically significant.

In 1992, the General Accounting Office (GAO) completed a meta analysis of existing WIC studies that yielded estimates of cost savings attributable to WIC (GAO, 1992). The meta analysis included 17 studies of WIC impacts on rates of low birthweight that were

[56]Some early studies included prenatal care use and/or adequacy as separate outcome measures. While most of these studies found positive associations between WIC participation and measures of prenatal care, these estimates have largely been discounted because cross-sectional studies can not disentangle the direction of the effect. Higher rates and quality of prenatal care among WIC participants may result from either WIC referring women to prenatal care or prenatal care providers referring enrolled women to WIC. Because of this limitation and the fact that prenatal care is now almost universally used as a covariate rather than an outcome, results of analyses that looked at the impacts of WIC on prenatal care are not included in this summary.

Table 18—Findings from studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs

	Significant impact	No significant impact		Significant impact
Outcome	Participants higher	Participants higher/same	Participants lower	Participants lower
Mean birthweight	Reichman (2003) [1 State] Kowaleski-Jones (2002) [national] Buescher (2000) [1 State] Brien (1999) [national] {Blacks} Gordon (1995) [national][1] Mays-Scott (1991) [1 site] Devaney (1990/91) [5 States][2] New York State (1990) [1 State] Rush (1988a) [national] Stockbauer (1987) [1 State] {Blacks} Schramm (1986) [1 State] Stockbauer (1986) [1 State] {non-White}[3] Metcoff (1985) [1 site] {smokers} Heimendinger (1984) [3 neighborhoods] Kennedy (1984) [4 areas in 1 State][4] Bailey (1983) [2 sites] {smokers} Kennedy (1982) [4 areas in 1 State] Edozien (1979) [national] {3+ months on WIC}	Brown (1996) [1 site] Stockbauer (1986) [1 State] {White}[5] Collins (1985) [6 counties] Metcoff (1985) [1 site] {nonsmokers} Schramm (1985) [1 State] Kotelchuck (1984) [1 State][6] Bailey (1983) [2 sites] {nonsmokers} Silverman (1982) [1 county]	Brien (1999) [national] {Whites} Rush (1988d) [national] Stockbauer (1987) [1 State] {White} Edozien (1979) [national] {< 3 months on WIC}	
Mean gestational age	Gordon (1995) [national] Devaney (1990/01) [5 States] New York State (1990) [1 State] Rush (1988a) [national] Stockbauer (1987) [1 State] Stockbauer (1986) [1 State][7] Kennedy (1984) [4 areas in 1 State] Kotelchuck (1984) [1 State] Edozien (1979) [national]	Brien (1999) [national] {Blacks}[8]	Brien (1999) [national] {Whites} Rush (1988d) [national]	

See notes at end of table.

Continued—

Table 18—Findings from studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants lower	Participants lower/same	Participants higher	Participants higher
Likelihood of low birthweight (<2,500 gm)	Roth (2004) [1 State][9] Finch (2003) [national] Gregory (2003) [1 State] {Blacks} Reichman (2003) [1 State] Buescher (2000) [1 State][10,11] Ahluwalia (1998) [1 State] Covington (1995) [national] {except subgroup noted} Gordon (1995) [national][12] Buescher (1993) [1 State] Devaney (1990/91) [5 States] New York State (1990) [1 State] Stockbauer (1987) [1 State] {Blacks} Schramm (1986) [1 State] Schramm (1985) [1 State] Stockbauer (1986) [1 State] {non-White}[13] Kotelchuck (1984) [1 State][4] Kennedy (1982) [4 areas in 1 State]	Gregory (2003) [1 State] {non-Blacks} Brien (1999) [national] {Blacks}[8] Brown (1996) [1 site] Rush (1988a) [national] Simpson (1988) [1 State] Stockbauer (1987) [1 State] {White} Stockbauer (1986) [1 State] {White} Bailey (1983) [2 sites] Kennedy (1984) [4 areas in 1 State] Silverman (1982) [1 county]	Hogan and Park (2000) [national] Brien (1999) {national] {Whites} Rush (1988d) [national]	Covington (1995) [national] {annual income > 12,000 and no public aid}
Likelihood of very low birthweight (<1,500 gm)	Roth (2004) [1 State][9] Gregory (2003) [1 State] {Blacks} Buescher (2001) [1 State][10,11] Hogan and Park (2000) [national] Covington (1995) [national] Gordon (1995) [national][14] Buescher (1993) [1 State] Devaney (1992) [4 States] New York State (1990) [1 State] Stockbauer (1987) [1 State] {Blacks}	Gregory (2003) [1 State] {non-Blacks} Devaney (1992) [1 State][15] Stockbauer (1987) [1 State] {Whites} Rush (1988d) [national]	Rush (1988a) [national]	

See notes at end of table.

Continued—

Table 18—Findings from studies that examined the impact of prenatal WIC participation on birth outcomes, including associated health care costs—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants lower	Participants lower/same	Participants higher	Participants higher
Mean Medicaid/health care costs	Gregory (2003) [1 State] Buescher (1993) [1 State] New York State (1991) [1 State][16] Devaney (1990/91) [4 States] Schramm (1986) [1 State] Schramm (1985) [1 State]	Devaney (1990/91) [1 State] Paige (1983) [4 counties][17]		
Likelihood of premature birth (<36-37 weeks gestation)	Gordon (1995) [national] Devaney (1990/91) [5 States] New York State (1990) [1 State] Rush (1988a) [national] Stockbauer (1987) [1 State]	Brien (1999) [national] {Blacks}[8] Frisbie (1997) [national][18] Rush (1988d) [national] Kotelchuck (1984) [1 State][6]	Brien (1999) [national] {Whites}	
Likelihood of intrauterine growth retardation/small-for-gestational-age birth	Frisbie (1997) [national] Stockbauer (1986) [1 State][7]	Stockbauer (1987) [1 State] {Blacks} Kennedy (1984) [4 areas in 1 State]		Stockbauer (1987) [1 State] {Whites}
Neonatal mortality (birth through early infancy, approximately 1 month)	Gregory (2003) [1 State] {Blacks} Moss (1998) [national] Devaney (1993) [4 States] Joyce (1988) [national] {Blacks} Stockbauer (1986) [1 State] {non-Whites} Kennedy (1984) [1 State][19] Kotelchuck (1984) [1 State]	Gregory (2003) [1 State] {non-Blacks} Brien (1999) [national] {Whites}[8] Gordon (1995) [national][14] Joyce (1988) [national] {Whites} Rush (1988a) [national] Rush (1988d) [national][19] Stockbauer (1987) [1 State] Schramm (1986) [1 State]	Brien (1999) [national] {Blacks}[8] Devaney (1993) [1 State]	Stockbauer (1986) [1 State] {Whites}

See notes at end of table.

Continued—

Table 18—Findings from studies that examined birth outcomes, including associated health care costs, by prenatal WIC participation status—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants lower	Participants lower	Participants higher	Participants higher
Infant mortality (later infancy through first year of life)	Gregory (2003) [1 State] {Blacks}[20] Devaney (1993) [4 States]	Brown (1996) [1 site] Gordon (1995) [national][14] Devaney (1993) [1 State] Rush (19881) [national]	Brien (1999) [national][21]	

Notes: Cell entries show the senior author's name, the publication date, and the scope of the study (for example, national vs. 1 city or 1 State). Where findings pertain only to a specific subgroup rather than the entire study population, the cell entry also identifies the subgroup {in brackets}.

Nonsignificant results are reported in the interest of providing a comprehensive picture of the body of research. As noted in chapter 1, a consistent pattern of nonsignificant findings may be indicative of a true underlying effect, even though no single study's results would be interpreted in that way. Readers are cautioned to avoid the practice of "vote counting," or adding up all the studies with particular results. Because of differences in research design and other considerations, findings from some studies merit more consideration than others. The text discusses methodological limitations and emphasizes findings from the strongest studies.

For studies that estimated more than one model, findings reported here reflect results for primary or baseline models. Unless otherwise noted, findings for alternative models were not qualitatively different.

Findings reported for Brien and Swann (1999) are based on two-stage model that controlled for selection bias, which was preferred by authors. The model did not control for variables that the authors considered to be endogenous, including age, income, living situation, use and adequacy of prenatal care, smoking, and use of alcohol and drugs. Unless otherwise noted, significance of effect (but not necessarily the direction) was the same for a model that defined WIC participation on the basis of status during the first trimester and a fixed effects model that estimated differences between pregnancies for the same women.

Findings reported for Kennedy and Kotelchuk (1984) are based on analyses for total sample. The paper also reports results by racial group for some outcomes; however sample sizes for non-Whites are small.

[1] Difference was positive but not significant in model that controlled for gestational age, models for three of the four gestational-age cohorts, and model that limited WIC participants to those who participated in first 6 months of pregnancy. Difference was negative, but not significant, in model for 28-week cohort.

[2] Size of impact was substantially greater among infants born prematurely (< 37 weeks gestation).

[3] Mixed results depending on comparison group used. Two out of three comparisons found positive, significant impact among non-white participants.

[4] Dose-response analyses found no significant impact.

[5] Mixed results depending on comparison group used, but estimates for one comparison were identical and for another were off by one gm.

[6] Authors reported significant difference at $p < 0.10$.

[7] Mixed results depending on comparison group used. Two out of three comparisons found positive, significant impact for both Whites and non-Whites.

[8] Impact was positive and significant in fixed-effects model.

[9] Significant difference noted for each of five annual cohorts (1996-2000), as well as for the full sample.

[10] Difference was favorable to WIC participants but not statistically significant for 37-week cohort. The number of very-low-birthweight infants in this sample was very small (28 vs. 742 in full sample).

[11] Difference was not statistically significant in model that controlled for gestational age.

[12] Impact was positive but not significant for 28- and 32-week cohorts and positive and significant for 36- and 40-week cohorts.

[13] Mixed results depending on comparison group used, but two comparisons showed positive WIC impact and one of these was significant.

[14] No significant impact in models for four gestational-length cohorts.

[15] mpact was not significant in models that limited WIC participants to those who enrolled by 30 weeks and 32 weeks.

[16] Reported significantly shorter hospital stay for WIC infants in all three insurance groups; however, analysis used simple t-tests. Medicaid hospital costs for WIC infants were lower than non-WIC infants, but the statistical significance of the difference was not tested.

[17] No statistical tests performed.

[18] Impact was positive and significant for probability of heavy preemie (WIC participants less likely to have heavy preemie).

[19] Finding reflects impact on *fetal* death rate rather than neonatal death rate because data were available only up to the time of birth.

[20] Difference among non-blacks was not statistically significant, however, because data were not presented, could not determine direction of difference.

[21] Impact was positive and significant, for blacks, in fixed-effects model.

deemed to be adequate in sample size and design. All of these studies are included in tables 17 and 18.[57] By statistically combining the results of these studies, GAO researchers estimated WIC's effect on reducing the incidence of low birthweight as well as the incidence of very low birthweight.[58] They then used this information to estimate the number of infants born in 1990 who would have been born with low birthweights if their mothers had not received WIC benefits. Finally, cost savings attributable to WIC were determined by combining the estimate of averted low birthweight and very low birthweight infants with information on the excess costs associated with caring for these infants. Cost estimates included short-term hospital costs, expected long-term disability costs, and expected special education costs. A substantial proportion of total costs were attributable to medical care costs in the first year of life.

The GAO researchers concluded that prenatal WIC participation reduced the incidence of low birthweight by 25 percent (estimates from the studies examined ranged from 10 percent to 43 percent) and the incidence of very low birthweight by 44 percent (study estimates ranged from 21 to 53 percent). When these estimates were applied to 1990 births and associated costs, result indicated that providing WIC services to mothers who delivered babies in 1990 would ultimately save more than $1 billion in costs for Federal, State, local, and private payers. Savings to the Federal Government were estimated at $337 million. These findings are the source of an oft-cited claim that "every dollar invested in [prenatal] WIC saves $3.50 in other costs."[59]

In commenting on the GAO report, USDA officials raised appropriate concerns that GAO's conclusions overstated the impact of WIC because (1) the reviewed studies used data collected between 1982 and 1988, but both Medicaid and WIC had changed substantially since then, (2) none of the reviewed studies was generalizable to the entire WIC population, and (3) GAO researchers relied most heavily on findings from the WIC-Medicaid Study, which was largely limited to the very lowest income WIC participants (GAO, 1992).[60] USDA officials also stressed that the report did not adequately caveat its findings in recognition of the selection-bias problem.

Since the GAO meta analysis was completed, 13 additional studies have examined WIC's impact on birthweight and/or Medicaid costs using techniques that were comparable to or better than those used in the studies reviewed by GAO. These include studies that involved national datasets (Finch, 2003; Kowaleski-Jones and Duncan, 2002: Hogan and Park, 2000; Brien and Swann, 1999; Covington, 1995; Gordon and Nelson, 1995), as well as studies that focused on one State (Roth et al., 2004; Gregory and deJesus, 2003; Reichman and Teitler, 2003; Buescher and Horton, 2000; Ahluwalia et al., 1998). Two other studies used data from the WIC-Medicaid Study (Devaney, 1992) and data from one hospital (Brown et al., 1996). With the exception of Brown et al. (1996), all of these studies reported a significant WIC impact overall or for at least one subgroup. Moreover, the studies by Kowaleski-Jones and Duncan (2002) and Brien and Swan (1999) included controls for selection bias that the authors deemed successful.

Taken as a whole, the available body of research provides strong, suggestive evidence that WIC has a positive impact on mean birthweight, the incidence of low birthweight, and several other key birth outcomes, and that these positive effects lead to savings in Medicaid costs. Even recognizing the pervasive self-selection problem and the fact that virtually all studies have other limitations that limit generalizability, the consistency of the results across studies is noteworthy. This is especially true when one considers that the bulk of the literature is comprised of relatively large, well-conducted studies, includes both national samples and State-level data that essentially amount to point-in-time censuses, and includes data from a number of different time periods.

Other reviewers have reached similar conclusions (Rossi, 1998; Currie, 1995). Currie (1995) offers the following observation:

> Without knowing more about the selection mechanism underlying participation in the program, it is difficult to

[57]In the GAO meta analysis, each of the five States studied by Devaney et al. (1990/91) in the WIC-Medicaid Study were considered as separate studies. Other studies included in the meta analysis were Silverman (1982), Kennedy et al. (1982), Kennedy and Kotelchuck (1984), Bailey et al. (1983), Metcoff et al. (1985), Stockbauer (1986, 1987), Schramm (1985, 1986), the NWE (Rush et al., 1986, 1988a, 1988d), and Buescher et al. (1993). (The GAO report used a 1991 version of the work Buescher and his colleagues published in 1993).

[58]Estimates related to the incidence of very low birthweight are based on data from 5 of the 17 studies that provided separate estimates for incidence of low and very low birthweight. In estimating reductions in very low birthweight attributable to WIC and the associated cost savings, the authors applied results from these studies to the other 12 studies.

[59]The $3.50 savings (calculated in 1990 dollars and assuming a 2-percent discount rate) accrues over 18 years. Savings in the first year of life were estimated at $2.89 per Federal dollar spent on prenatal WIC participation.

[60]The WIC-Medicaid Study estimated, with the appropriate caveats, that every dollar spent on prenatal WIC participation generated more than $1.00 in Medicaid savings. This analysis considered only Medicaid expenditures during the first 60 days after birth.

> assess the probable direction of the bias. However, the factors governing selection into the WIC Program are likely to vary considerably over time and across sites. "...Hence, the fact that the estimated effects are remarkably consistent across samples drawn from different states and at different times suggests that the positive results are not entirely driven by the selection of women who are likely to have good outcomes into the program." (p. 100).

Thus, the evidence that WIC participation during pregnancy positively influences birth-related outcomes is fairly convincing. Beyond that, however, little else is clear. Because of the design characteristics that contribute to inherent underestimation or overestimation of WIC impacts and the wide range of reported estimates, it is difficult to characterize the relative size of WIC's impact—for example, the estimated reduction in the prevalence of low birthweight infants—with any confidence. Moreover, subgroup analyses by some researchers suggest that WIC impacts may be stronger among Blacks and other minorities than among Whites (Gregory and deJesus, 2003; Brien and Swann, 1999; Stockbauer, 1986, 1987) and among those at the lowest income levels (Finch, 2004; GAO, 1992).

In addition, many important changes have taken place since the data used in most of this research were collected. These changes may influence the extent to which findings from previous research apply to today's WIC program. The most noteworthy changes include the following:

- A substantially higher level of program penetration in most areas of the United States than was present in the mid-to-late 1980s (that is, most eligible prenatal applicants are able to enroll and waiting lists tend to be the exception rather than the rule).

- More generous Medicaid income-eligibility criteria for pregnant women (including some that exceed the WIC cutoff of 185 percent of poverty), which infer automatic income-eligibility for WIC.

- The use of standardized nutritional risk criteria.

Welfare reform legislation, which did not affect WIC directly, may also have affected the circumstances of both WIC participants and nonparticipants. Any of these changes may influence both the presence and size of WIC impacts as well as variation in impacts across subgroups.

Two studies by Buescher and his colleagues illustrate how the prenatal WIC population in one State has changed over time. Both of these studies were limited to Medicaid participants in North Carolina. At the time of the first study in 1988, the Medicaid income-eligibility cutoff was 100 percent of poverty, and a total of 21,900 Medicaid births were included in the study (Buescher et al., 1993). At the time of the second study in 1997, the Medicaid cutoff for pregnant women was 185 percent of poverty, and the number of Medicaid births was almost double, at roughly 43,000 (Buescher and Horton, 2000). Although both studies found that WIC decreased the likelihood of low birthweight and very low birthweight, the magnitude of the differences between WIC participants and nonparticipants was smaller in 1997 than it had been in 1988 (odds ratios of 1.36 vs. 1.45 for low birthweight and 1.90 vs. 2.15 for very low birthweight).

Initiation and Duration of Breastfeeding: Research Overview

Impacts on breastfeeding are discussed in this section because, as mentioned previously, any impact WIC may have on the decision to breastfeed is clearly tied to nutrition education and/or breastfeeding promotion services provided to the mother during pregnancy. (Impacts on breastfeeding duration and other infant feeding practices may be influenced by WIC services provided after birth.)

The literature search identified few studies that assessed the impact of WIC on breastfeeding behaviors. Many identified studies examined the impact of specific breastfeeding promotion strategies/programs on *WIC participants*. However, such studies do not address the impact of the WIC program per se. That is, they provide no information on what breastfeeding initiation and duration rates would look like in the absence of the WIC program.

Official WIC policy has always encouraged breastfeeding. Both programmatic and research interest in this topic grew in the late 1980s and early 1990s, however, when national survey data indicated that breastfeeding rates were declining nationwide (as the WIC program was growing) and that the rate of breastfeeding among WIC participants was less than the national average and less than the rate for low-income nonparticipants.

Many investigators have examined predictors of breastfeeding behaviors. Results have been very consistent and have demonstrated that women who are African American, less educated, low-income, and younger are less likely to breastfeed than other women. These demographic characteristics are also associated with an increased likelihood of WIC participation, so it is not surprising that studies that have included WIC participation among the list of potential breastfeeding predictors have almost invariably found a negative association or no association between WIC participation and breastfeeding.

These negative statistics have prompted substantial commentary and questions over the years, particularly: Does the formula provided by WIC act as a disincentive to breastfeeding? and Does the WIC program devote adequate resources to breastfeeding promotion? Obtaining reliable answers to these questions is complicated by substantial selection bias that makes it more likely that researchers will find a negative association between WIC participation and breastfeeding. As just noted, the demographic characteristics of women who are least likely to breastfeed closely parallel the characteristics of women who are most likely to participate in WIC. In addition, it is reasonable to assume that women who have decided to formula-feed may be more likely to participate in WIC than women who have elected to breastfeed in order to obtain the free formula. The incentive to participate may be substantially reduced for women who have decided to breastfeed.

The literature review identified nine studies that attempted to estimate the impact of WIC participation on breastfeeding behaviors (table 19). Studies that used only t-tests or correlation coefficients to examine this relationship, without controlling for measured differences between groups, are not included. As just noted, these studies are virtually guaranteed to find a negative association or no association between WIC participation and breastfeeding because of the demographic characteristics of WIC participants.

Two components of the NWE examined breastfeeding in a fairly limited way (Rush et al., 1988d; 1988c) (Group I). Five studies used national survey data to study the impact of WIC on breastfeeding (Group II). Two of these studies used the NMIHS, one study used the NLSY, and two studies, including one study conducted by the GAO in response to a congressional request, used the Ross Laboratory Mother’s Survey (RLMS). The RLMS, in various forms, has been ongoing for more than 40 years and is used to document national trends in infant feeding. The RLMS includes a mail survey of a large nationally representative sample of mothers of 6-month-old infants. The sample represents 70-82 percent of all new mothers in the United States (Ryan, et al., 1991). Response rates have generally been lower than desired for scientific surveys. Over the years, low-income women have exhibited the lowest response rate and have therefore been oversampled. Weights used in analyzing survey data are specifically designed to account for differences in response rates and coverage of various population subgroups (GAO, 1993; Ryan et al., 1991).

Finally, two State and local studies examined WIC impacts on breastfeeding and infant feeding practices (Group III). Burstein and her colleagues (1991) reported preliminary impact estimates from the field test of the WIC Child Impact Study. A much smaller, local study looked at the impact of multiple spells of participation on breastfeeding rates among Hmong and Vietnamese WIC participants in northern California (Tuttle and Dewey, 1994).

Initiation and Duration of Breastfeeding: Research Results

In the NWE, the Longitudinal Study of Women found that WIC participants were both less likely to plan to breastfeed (breastfeeding intention) and less likely to initiate breastfeeding in the hospital than income-eligible nonparticipants (Rush et al., 1988d) (table 20). However, study investigators discounted the finding about breastfeeding initiation because they believed it was influenced by a substantial amount of missing data in the hospital records that provided data for the analysis.

A study completed by Ryan and his colleagues in 1991, using RLMS data for 1984 and 1989, reported that breastfeeding rates, and extended breastfeeding in particular (6 months or more), declined disproportionately among WIC participants during this period. Even after controlling for measured differences between groups, nonparticipants were 1.5 times more likely than WIC participants to initiate breastfeeding in the hospital. This study contributed substantially to the debate about the role of the WIC program in promoting breastfeeding.

The reliability of these findings was called into question because of concerns about the adequacy of the single survey item used to classify WIC participants and nonparticipants and lack of attention to the issue of selection bias (Tognetti et al., 1991). The survey item used to identify WIC participants asked whether the mother or the target infant participated in WIC at any time since the infant’s birth. This composite question did not allow differentiation of women who participated in WIC prenatally (and therefore had the opportunity to be exposed to WIC breastfeeding promotion advice and activities)

Table 19—Studies that examined the impact of the WIC program on breastfeeding

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Group I: National evaluations						
Rush et al. (1988c) (NWE)	Breastfeeding initiation and duration	Primary data collection in 174 WIC sites and 55 prenatal clinics (1983-84)	Random sample of infants and children of women included in the longitudinal study of women (see Rush et al., 1988d below) (n=2,370)	Participant vs. nonparticipant	Participation dummy based on age of inception into WIC, including prenatally	Multivariate regression
Rush et al. (1988d) (NWE)	Breastfeeding intention and initiation	Primary data collection in 174 WIC sites and 55 prenatal clinics (1983-84)	Nationally representative sample of pregnant WIC participants and comparison group receiving prenatal care in surrounding public health clinics or hospitals (n=3,935)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Group II: Secondary analysis of national surveys						
Chatterji et al. (2002)	Breastfeeding initiation and duration	1989-95 NLSY	(1) NLSY children born between 1990 and 1995 (n=1,282) (2) Low-income NLSY children born between 1991 and 1995 (n=517) (3) NLSY children born between 1989 and 1995, with at least one other sibling born during the same period (n=970)	Participant vs. nonparticipant	Participation dummy	(1) (2) Multivariate regression, including attempt to control for selection bias (3) Fixed-effects model

See notes at end of table. Continued—

Table 19—Studies that examined the impact of the WIC program on breastfeeding—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Balcazar et al. (1995)	Breastfeeding intention	1988 NMIHS live births	Mexican-American and non-Hispanic White women who were not undecided about infant feeding plans prior to the infant's birth (n=4,089)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
GAO (1993)	Breastfeeding initiation	1989-92 RLMS	Nationally representative sample of mothers of 6-month-old babies. Analysis included all respondents with complete data for questions of interest (n=79,428)[3]	Prenatal participants vs. nonparticipants and postpartum-only participants	Participation dummy	Multivariate regression
Schwartz et al. (1992)	Breastfeeding initiation and duration	1988 NMIHS	WIC participants and income-eligible nonparticipants (n=6,170)	Participants who received advice to breastfeed compared with participants who did not receive advice and to income-eligible nonparticipants	Participation dummy and advice dummy	3-stage regression with selection-bias adjustment
Ryan et al. (1991)	Breastfeeding initiation and duration	1984 and 1989 RLMS	Respondents in 1984 and 1989 (n=120,334)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Group III: State and local studies						
Tuttle and Dewey (1994)	Breastfeeding initiation	Primary data collection in WIC clinics and neighborhoods in 1 northern California community	Hmong and Vietnamese WIC participants whose youngest child was less than 1 year (n=122)	Participant vs. nonparticipant	Dose response: Number of times previously participated in WIC	Multivariate regression

See notes at end of table.

Continued—

Table 19—Studies that examined the impact of the WIC program on breastfeeding—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Burstein et al. (1991)	Breastfeeding initiation and duration	Primary data collection in Florida and North Carolina (1990-91)	Random sample of WIC and income-eligible infants (6 months old) stratified by birthweight (n=807)	Participant vs. nonparticipant	Participation dummy	Multivariate regression, including attempt to control for selection bias

[1]Data sources:
NLSY = National Longitudinal Survey of Youth.
NMIHS = National Maternal and Infant Health Survey.
RLMS = Ross Laboratories Mother's Survey.

[2]Unless the description of the study sample indicates that a comparison group was limited to nonparticipants who were income eligible for WIC or known to be Medicaid participants, all income levels were included in the comparison group.

[3]Overall response rate for survey was approximately 50 percent. After excluding cases with incomplete data, analysis sample comprised only 34 percent of the initial survey sample.

Table 20—Findings from studies that examined the impact of the WIC program on breastfeeding

	Significant impact	No significant impact		Significant impact
Outcome	Participants higher	Participants higher	Participants lower	Participants lower
Intention to breastfeed	Balcazar (1995) [national] {with advice}[1]		Rush (1988d) [national]	Balcazar (1995) [national] {overall}[1]
Breastfeeding initiation	Tuttle (1994) [1 community][2] Schwartz (1992) [national] {advice}	Rush (1998c) [national]	Burstein (1991) [2 States] Rush (1998d) [national][3, 4]	Chatterji (2002) GAO (1993) [national][3,5] Schwartz (1995) [national] {no advice} Ryan (1991) [national][3]
Duration of breastfeeding		Schwartz (1992) [national] {no advice} Rush (1998c) [national]	Chatterji (2002)[6] Schwartz (1992) [national] {advice}	Ryan (1991) [national][7]

Notes: Cell entries show the senior author's name, the publication date, and the scope of the study (for example, national vs. 1 city or 1 State). Where findings pertain only to a specific subgroup rather than the entire study population, the cell entry also identifies the subgroup {in brackets}.

Nonsignificant results are reported in the interest of providing a comprehensive picture of the body of research. As noted in chapter 1, a consistent pattern of nonsignificant findings may indicate a true underlying effect, even though no single study's results would be interpreted in that way. Readers are cautioned to avoid the practice of "vote counting," or adding up all the studies with particular results. Because of differences in research design and other considerations, findings from some studies merit more consideration than others. The text discusses methodological limitations and emphasizes findings from the strongest studies.

Findings reported for Chatterji et al. (2002) are based on the single-equation model, which the authors favored (see text).

Findings reported for Burstein et al. (1991) were consistent for single-equation and selection-bias-adjusted models.

[1] Overall, WIC participants were significantly less likely than nonparticipants to plan to breastfeed, either exclusively or in combination with formula feeding. However, women who participated in WIC and reported receiving advice to breastfeed were significantly more likely to plan to breastfeed.

[2] Number of times woman had previously participated in WIC was positively associated with initiation of breastfeeding.

[3] Limited to initiation of breastfeeding before hospital discharge.

[4] Results are highly suspect because data were missing for almost half of the subjects. The authors suspect that the relevant data element on hospital records was disproportionately skipped for women who did not breastfeed.

[5] Result reported is for comparison of prenatal WIC participants vs. nonparticipants. Comparison of prenatal and postpartum-only WIC participants revealed virtually no difference between the two groups.

[6] Difference was statistically significant in fixed-effect model.

[7] Based on odds ratio of breastfeeding when infant is 6 months old.

from those who participated only after the birth of the child. The combination of prenatal and postpartum participants and, potentially, infant-only participants, may have diluted the apparent WIC effect.

GAO (1993) used RLMS data for 1992 to address congressional questions about the effectiveness of WIC's current breastfeeding promotion efforts.[61] GAO's analysis included a multivariate regression to investigate the relationship between prenatal WIC participation and initiation of breastfeeding in the hospital. Results showed that, after controlling for differences in measured characteristics (including education, income, race, and a variety of other characteristics known to be associated with breastfeeding rates), prenatal WIC participants were just as likely as postpartum-only participants to initiate breastfeeding. Moreover, prenatal WIC participants were significantly less likely than nonparticipants to initiate breastfeeding. Study authors cautioned that the analysis did not control for selection bias and that unmeasured characteristics, whether related to the woman herself or her interaction with the WIC program, may have contributed to the observed differences between WIC participants and nonparticipants.

In 1992, Schwartz et al. used data from the NMIHS to examine the impact of WIC on breastfeeding. They estimated three equations jointly and simultaneously to control for self-selection and to model the decision to initiate breastfeeding and, for those who breastfed, the duration of breastfeeding. The analysis looked at the combined influence of participating in WIC and receiving advice and encouragement from WIC staff to breastfeed. In the joint model, the coefficient for WIC participation was significant and negative and the coefficient for receiving breastfeeding advice was significant and positive. The interpretation is that the impact of WIC on breastfeeding was mediated by whether the woman was encouraged by WIC staff to breastfeed her infant. After controlling for socioeconomic differences, prenatal WIC participants who reported having received advice/encouragement to breastfeed were more likely to initiate breastfeeding than either participants who did not receive such advice or income-eligible nonparticipants. In contrast, WIC participants who did not report receiving such advice/encouragement to breastfeed were significantly less likely to initiate breastfeeding than income-eligible nonparticipants. Neither WIC participation nor receipt of breastfeeding advice had a significant impact on the duration of breastfeeding.

Balcazar et al. (1995) used NMIHS data to assess predictors of breastfeeding intentions and found a similar relationship between receiving advice/encouragement to breastfeed and reported breastfeeding intentions. While the relationship between WIC participation and breastfeeding intentions was negative overall, the relationship was positive among women who reported receiving breastfeeding advice/encouragement from WIC staff. In addition, receiving advice/encouragement to formula feed was negatively associated with breastfeeding intentions.

An obvious concern about both of these studies is whether self-reported data about receiving advice are biased in any way. For example, women who breastfed could have been more apt to report having gotten advice to do so. Or, WIC staff could have provided breastfeeding advice/encouragement to women who indicated an interest in breastfeeding. To address this issue, Schwartz and his colleagues estimated an alternative, two-stage equation that omitted the breastfeeding advice variable. The alternative model yielded results that were substantially different from the results (reported above) for the three-stage model. In the two-stage model, the coefficient for WIC participation, which was strongly and significantly negative in the initial three-stage model, was positive and not statistically significant, suggesting that WIC participation had no impact on breastfeeding initiation. The fact that the two models produced such divergent results is somewhat troubling. Given the potential problems with the reliability of data on breastfeeding advice, one must question the authors' uncaveated preference for the three-stage model.

The most recent study of WIC's impact on breastfeeding was completed in 2002 by Chatterji and colleagues. They used data from the NLSY to examine breastfeeding initiation and duration among children born between 1989 and 1995. WIC participation was defined based on the mother's participation during the year of the child's birth.[62] No information was available on whether WIC participants received advice or encouragement to breastfeed.

[61] Although recognizing the potential problem of nonresponse bias in the RLMS data, GAO researchers pointed out that survey weights were specifically designed to deal with this issue and that estimates of national breastfeeding rates derived from the RLMS were consistent with those of key government-sponsored national survey efforts, including the NMIHS and the National Survey of Family Growth (NSFG).

[62] The authors also completed parallel analyses using a variable that defined WIC participation based on participation during pregnancy or at the time of birth. Results of these analyses were reportedly "very similar" but were not presented. In addition, for children born in 1994, WIC participation was proxied based on WIC participation during the year that preceded the child's birth because data on WIC participation were not available for 1994.

The authors used two different approaches to control for selection bias—a two-stage model and a fixed-effects model that used data for sibling pairs. To model the participation decision in the two-stage model, the authors used variables that represented State-level WIC and Medicaid policies. Information on State-level WIC policies were obtained from the biennial WIC Participant and Program Characteristics (WIC PC) Studies, so assigning values to individual sample members was somewhat imprecise. Values for children born in years for which WIC PC data were not available (1991, 1993, and 1995) were assigned based on WIC PC data for the following year. In addition to Medicaid income eligibility cutoffs, State-level factors considered in the model included links between WIC and Medicaid, TANF, and FSP, WIC policies about income documentation, and the presence of nutrition-based restrictions on WIC food packages.

The authors describe several other variables that were considered but ultimately excluded from the model because they did not pass the test of over-identifying restrictions or "were very poor predictors of WIC participation." These variables included monthly (as opposed to less frequent) voucher issuance, nutritional risk criteria, nonnutrition-based food package restrictions (for example, restrictions related to package size or brand), and costs of WIC food packages. The fact that these variables were excluded from the final model suggests that the selection-adjustment model, like those used in research on birth outcomes, was very sensitive to changes in specification.

The authors reported results for a standard regression (baseline model), the selection-adjusted model, and the fixed-effects model. For baseline and selection-adjusted models, impacts were estimated for the full sample as well as for a low-income sample. Outcomes included breastfeeding initiation and whether breastfeeding lasted for 16 weeks. For the fixed-effects model, the dependent variable was the number of weeks the child was breastfed, including zeros for nonbreastfed infants. The fixed-effects model included 970 children who had one or more siblings in the sample; however, only about 15 percent of these children lived in a family where WIC participation varied across siblings.

Results of baseline regressions showed a significant, negative association between WIC participation and breastfeeding initiation in both the full sample and the low-income sample. Coefficients for breastfeeding duration (whether infant was breastfed for at least 16 weeks) were also negative for both samples, but differences between WIC participants and nonparticipants were not statistically significant. Results of the two-stage models yielded no significant findings, although coefficients for WIC participation were consistently negative. The fixed-effects model found that WIC participation had a significant, negative effect on breastfeeding duration (mean number of weeks breastfed).

Although the authors say that their instruments performed fairly well, they ultimately rejected the selection-adjusted results—which found no significant WIC effect—in favor of the baseline regression results-which found a negative WIC effect. The rationale for this decision was that Hausman tests suggested that WIC participation was not endogenous. This conclusion is open to question, given that the Hausman test depends heavily on the availability of good instruments (Carlson and Senauer, 2003). Moreover, the authors clearly stated that their hypothesis was that "despite the important efforts the WIC program has made to increase breastfeeding during the 1990s, WIC participation is still associated with lower rates of breastfeeding because of the valuable infant formula available to participants."

Viewed in concert, the available studies provide no firm ground for making causal inferences about the impact of WIC on breastfeeding initiation or duration. Statistics do show, however, that breastfeeding rates among WIC participants have been increasing. The RMLS shows a 69-percent increase between 1990 and 2000 in the percentage of WIC mothers who initiate breastfeeding and a 145-percent increase in the percentage who were still breastfeeding at 6 months (Oliveira, 2003). This increase cannot be attributed to the WIC program because breastfeeding rates have been climbing for the population overall. However, since the late 1980s, USDA has specifically targeted promotion of breastfeeding in the WIC program (USDA/FNS, 2003a). For example, in 1989, P.L. 101-147 required that USDA develop standards for breastfeeding promotion and support and targeted $8 million for State-level efforts in this area. In 1992, P.L. 102-342 required that USDA establish a national breastfeeding promotion program. That same year, USDA instituted an enhanced food package for women who exclusively breastfeed. The enhanced package has additional amounts of juice, cheese, and legumes and includes carrots and canned tuna. In 1994, P.L. 103-448 increased the amount of money each State was required to devote to breastfeeding promotion and required that all States collect data on the incidence and duration of breastfeeding among WIC participants.

Finally, in 1998, P.L. 105-336 authorized the use of State administrative funds for the purchase or rental of breast pumps.

USDA has also implemented several breastfeeding promotion demonstrations and has disseminated findings and recommendations to State and local WIC agencies.[63] Evaluations of several of these demonstrations have found that breastfeeding promotion efforts during pregnancy can positively effect the initiation of breastfeeding among low-income women and that support during the postpartum period can positively influence breastfeeding duration. It is beyond the scope of this review to summarize these initiatives. However, the interested reader is referred to Weimer (1998), Bronner et al. (1994), and Sanders et al. (1990).

In 1996, USDA entered into a cooperative agreement with Best Start Social Marketing to develop and implement a national breastfeeding promotion campaign. The program was officially launched in August 1997. In 2003, the program was expanded to include training programs for WIC staff in implementing and managing peer counselor programs.

Clearly, WIC's focus on breastfeeding promotion has increased substantially since the NMIHS, which probably provided the best data, was conducted. While it makes sense for USDA to focus research efforts on identifying effective breastfeeding promotion strategies, it would also be useful to obtain updated impact analyses. Additional work with the NLSY data may provide some insights, and the Panel Study of Income Dynamics Child Development Supplement (PSID-CDS), which was implemented in 1997, may also be a useful data source. This longitudinal study collects information on both breastfeeding and WIC participation (Logan et al., 2002).

Nutrition and Health Characteristics of Pregnant Women: Research Overview

Ten of the identified studies looked at the impact of prenatal WIC participation on the nutrition or health characteristics of pregnant women themselves (table 21).[64] These studies include both of the national WIC evaluations (Group I), two studies that were based on secondary analysis of data from NHANES-III (Group II), one large State study (Group III), and five small, local studies (Group IV).

Nutrition and health characteristics examined in these studies include dietary intake (six studies), nutritional biochemistries—most often iron status or the prevalence of anemia (five studies), and weight gain during pregnancy (four studies). Like much of the research on WIC impacts, most of these studies are quite dated. At least three of the studies (Kennedy and Gershoff, 1982; Endres et al., 1981; Edozien et al., 1979) are based on data collected in the 1970s. One study published in 1983 (Bailey et al.) did not report the dates that data were collected. Only three studies (Roth et al., 2004; Mardis and Anand, 2000; Kramer-LeBlanc et al., 1999) are based on data that were collected after 1984. Roth et al. (2004)—the most recent study—focused primarily on impacts on birth outcomes; of the outcomes discussed in this section, only weight gain during pregnancy was included.

Both Mardis and Anand (2000) and Kramer-LeBlanc et al. (1999) examined dietary intakes and used bivariate t-tests to assess differences between participants and nonparticipants. Thus, while these studies are useful in understanding observed differences between dietary intakes of WIC participants and nonparticipants, based on relatively recent data, they do not provide valid estimates of WIC impacts. Both studies used the same dataset (NHANES-III) and the same samples. Mardis and Anand's analysis focused on food group intakes, while Kramer-LeBlanc's analysis looked at nutrient intakes.

None of the studies that examined the relationship between prenatal WIC participation and the nutrition and health characteristics of pregnant women attempted to control for selection bias. However, one of the local studies (Metcoff et al., 1985) is the only study known to have used a randomized design to study WIC impacts. The authors were able to use a randomized design because, at the time data were collected—early in the WIC program's history—the need for WIC services in the area under study exceeded available resources.

Nutrition and Health Characteristics of Pregnant Women: Research Results

Dietary Intake

With the exception of the descriptive analyses completed by Mardis and Anand (2000) and Kramer-LeBlanc et

[63]It is beyond the scope of this review to summarize these initiatives, however, the interested reader is referred to Weimer, 1998, Bronner et al., 1994, and Sanders et al., 1990.

[64]Fraker, Long, and Post (1990) attempted to examine the impact of WIC participation on all types of women (pregnant, breastfeeding, and postpartum combined) using the 1985 CSFII data. However, because of the very small sample of WIC participants (64), the authors recommended that results be considered investigatory only.

Table 21—Studies that examined the impact of the WIC program on nutrition and health outcomes of pregnant women

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Group I: National evaluations						
Rush et al. (1988d) (NWE)	Dietary intake, prevalence of anemia, pregnancy weight gain	Primary data collection and record abstractions in 174 WIC sites and 55 prenatal clinics (1983-84). Data were collected at time of enrollment into WIC or prenatal care and again at about 8 months gestation	Nationally representative sample of pregnant WIC participants and comparison group receiving prenatal care in surrounding public health clinics or hospitals (n=3,473)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Edozien et al. (1979)	Dietary intake, hemoglobin, prevalence of anemia, pregnancy weight gain	Primary data collection in 19 sites in 14 States (1973-76). Data were collected at time of WIC enrollment, approximately every 3 months until delivery, and once after delivery	Pregnant women who enrolled in WIC (n~2,885)[3]	(1) Nutritional biochemistries: Participants, before vs. after, separate groups (2) Dietary intake: Participants, before vs. after, same women	Dose response: Newly enrolling participants vs. participants with varying length of participation	Multivariate regression
Group II: Secondary analysis of national survey data						
Mardis and Anand (2000)	Dietary intake	1988-94 NHANES-III	WIC and income-eligible women (n=242)	Participant vs. nonparticipant	Participation dummy	Bivariate t-tests
Kramer-LeBlanc et al. (1999)	Dietary intake	1988-94 NHANES-III	WIC and income-eligible women (n=242)	Participant vs. nonparticipant	Participation dummy	Bivariate t-tests

See notes at end of table.

Continued—

Table 21—Studies that examined the impact of the WIC program on nutrition and health outcomes of pregnant women—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Group III: State-level studies using WIC participation files matched with Medicaid and/or birth record files						
Roth et al. (2004)	Pregnancy weight gain	Linked WIC, Medicaid, and vital statistics records for births in Florida between January 1996 and the end of December 2000	WIC and non-WIC Medicaid recipients who did not participate in high-risk obstetrical program (n=295,599)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Group IV: Other State and local studies						
Collins et al. (1985)	Pregnancy weight gain	Primary data collection in public health department clinics in 6 Alabama counties (1980-81)	WIC and non-WIC pregnant women (n=519)	Participant vs. nonparticipant	Participation dummy	Bivariate t-tests
Metcoff et al. (1985)	Variety of nutritional biochemistries	Primary data collection at a prenatal clinic in 1 hospital in Oklahoma (1983-84)	Income-eligible pregnant women selected at mid-pregnancy based on predicted birthweight; roughly equivalent numbers were predicted to have average-size babies vs. small or large babies (n=410)	Randomized experiment	Participation dummy	Multivariate regression
Bailey et al. (1983)	Dietary intake, nutritional biochemistries	Primary data collection at 1 WIC site and 1 non-WIC site in Florida (Dates not reported)	WIC and income-eligible nonparticipants were 30 weeks pregnant at time of recruitment and receiving identical prenatal care (n=101)	Participant vs. nonparticipant	Participation dummy	Analysis of variance

See notes at end of table.

Continued—

Table 21—Studies that examined the impact of the WIC program on nutrition and health outcomes of pregnant women—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Kennedy and Gershoff (1982)	Hemoglobin and hematocrit levels	WIC and medical records in WIC sites and non-WIC health facilities in 4 geographic areas of Massachusetts (1973-78)	WIC and WIC-eligible women[4] (n=232)	Participants vs. nonparticipants, before and after	Dose response: Number of WIC vouchers received	Multivariate regression
Endres et al. (1981)	Dietary intake	Dietary recalls for sample of pregnant WIC participants in 22 counties in Illinois (1978-79)	Newly enrolling pregnant WIC participants and participants who were on the program for 6 months or more (n=766)	Participants, before vs. after, separate groups	Participation dummy	Bivariate t-tests

[1] Data source: NHANES = National Health and Nutrition Examination Survey.
[2] Unless the description of the study sample indicates that a comparison group was limited to nonparticipants who were income eligible for WIC or known to be Medicaid participants, all income levels were included in the comparison group.
[3] Approximate maximum; sample size varied for each measure and analysis approach.
[4] Subset of participants in larger study focusing on impact of WIC on birthweight (see table 5). WIC-eligible women included in the nonparticipant group were wait-listed for WIC during their pregnancy, enrolled in WIC postpartum, or were women who received prenatal care at non-WIC health care facilities in same neighborhood but never enrolled in WIC.

al. (1999), all of the studies that have assessed the impact of WIC participation on the dietary intake of pregnant women are quite old. Indeed, aside from these two studies, the most recent study is the NWE (Rush et al.,1988d), which used data collected in 1983-84. Findings from such dated studies are subject to concerns about changes in the program and its participant groups over time, as discussed in the preceding section on birth outcomes.

In addition, a compelling argument can be made that impacts on diet-related outcomes are even more sensitive to temporal considerations than impacts on other outcomes. For example, the American food supply has changed dramatically since the early 1980s, with important implications for observed dietary intakes. Americans are eating substantially more grains than they were two decades ago, particularly refined grains, as well as record-high amounts of caloric sweeteners and some dairy products and near-record amounts of added fats (Putnam and Gerrior, 1999). Over time, myriad new products have come onto the market and food enrichment policies and standards have changed. In addition, food purchasing behaviors may have been influenced by including, for example, more food eaten away from home, smaller households, more two-earner and single-parent households, and increased ethnic and racial diversity (Putnam and Gerrior, 1999). These factors make the recent studies by Mardis and Anand (2000) and Kramer-LeBlanc et al. (1999), although strictly descriptive, important for understanding potential WIC impacts in the current environment.

All of the available research on dietary intakes of pregnant women is also subject to the limitations that affect most of the available research on diet-related impacts of FANPs, as discussed in chapter 2. All of the available studies used intake data for a single day and, therefore, provide weak estimates of individuals' usual dietary intake. In addition, in assessing intakes of food energy, vitamins, and minerals, researchers generally compared mean intakes of participants and nonparticipants relative to the Recommended Dietary Allowances (RDAs), or compared the proportion of individuals in each group with intakes below a defined cutoff, using a "more is better" approach in interpreting findings. None of the studies used the approach recently recommended by the IOM, which calls for use of data on usual intake and comparisons to defined Estimated Average Requirements (EARs) (IOM, 2001).

Consequently, the available research provides an imperfect picture of the substantive significance of observed differences in the dietary intakes of prenatal WIC participants and nonparticipants. It provides information on whether pregnant WIC participants consumed more or less energy and nutrients than pregnant nonparticipants, but this information cannot be used to conclude that WIC participants were more or less likely than nonparticipants to have adequate intakes.

Finally, as noted in chapter 2, the estimation of food and nutrient intake is an elaborate process that is subject to significant measurement error. This error may make detecting differences between participant and nonparticipant groups difficult.

Although subject to the above limitations, as well as to potential selection bias, evidence from early studies paints a reasonably consistent picture of WIC's impacts on the dietary intakes of pregnant women (table 22). The evidence suggests that WIC participation increased intakes of food energy and most of the nutrients examined, including four of the five nutrients traditionally targeted by the program—protein, vitamin C, iron, and calcium. Evidence for vitamin A, the fifth WIC nutrient, is less consistent, but vitamin A intake is especially difficult to estimate because the distribution is so skewed (vitamin A is concentrated in large amounts in relatively few foods). The early evidence also suggests that WIC increased intakes of vitamin B_6, which the program has targeted in recent years. The NWE (Rush et al., 1988d) also found that pregnant WIC participants consumed significantly more fat than nonparticipants. However, if intake is translated into percentage contribution to energy intake (using reported means for fat and energy), both groups consumed about 37 percent of energy from fat.

NWE authors (Rush et al., 1988d) pointed out that the relative magnitude of the incremental intakes observed among pregnant WIC participants were plausible in that they were comparable to the levels of supplementation achieved in smaller, intensively controlled clinical trials. Moreover, a thorough analysis of the sources of nutrients in women's diets completed for the NWE confirmed that differences in the diets of WIC participants and nonparticipants were attributable to consumption of WIC foods.

Other authors also found a relationship between observed differences in nutrient intake and the types of food provided in WIC food packages. Endres et al. (1981) found that pregnant WIC participants consumed milk, juice, and fortified cereals more often than pregnant nonparticipants (statistical significance

Table 22—Findings from studies that examined the impact of the WIC program on the dietary intakes of pregnant women

	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Food energy and macronutrients				
Energy[1]	Rush (1988d) [national] Endres (1981) [1 State]	Bailey (1983) [2 sites]	Kramer-LeBlanc (1999) [national]	
Protein	Rush (1988d) [national] Endres (1981) [1 State] Edozien (1979) [national]		Kramer-LeBlanc (1999) [national]	
Fat	Rush (1988d) [national]		Mardis (2000) [national] Kramer-LeBlanc (1999) [national]	
Saturated fat			Mardis (2000) [national] Kramer-LeBlanc (1999) [national]	
Carbohydrates	Rush (1988d) [national]	Kramer-LeBlanc (1999) [national][2]		
Vitamins				
Vitamin A[1]	Endres (1981) [1 State]	Rush (1988d) [national]	Kramer-LeBlanc (1999) [national]	
Vitamin B_6	Rush (1988d) [national] Bailey (1983) [2 sites] Endres (1981) [1 State]		Kramer-LeBlanc (1999) [national]	
Vitamin B_{12}	Rush (1988d) [national] Endres (1981) [1 State]		Kramer-LeBlanc (1999) [national]	
Vitamin C	Rush (1988d) [national] Endres (1981) [1 State] Edozien (1979) [national]	Kramer-LeBlanc (1999) [national]		
Vitamin D	Endres (1981) [1 State]		Kramer-LeBlanc (1999) [national]	
Vitamin E		Endres (1981) [1 State]	Kramer-LeBlanc (1999) [national]	

See notes at end of table.

Continued—

Table 22—Findings from studies that examined the impact of the WIC program on the dietary intakes of pregnant women—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Folate	Endres (1981) [1 State]	Bailey (1983) [2 sites]	Kramer-LeBlanc (1999) [national]	
Niacin[1]	Rush (1988d) [national] Endres (1981) [1 State]		Kramer-LeBlanc (1999) [national]	
Riboflavin	Rush (1988d) [national] Endres (1981) [1 State] Edozien (1979) [national]		Kramer-LeBlanc (1999) [national]	
Thiamin	Rush (1988d) [national] Endres (1981) [1 State] Edozien (1979) [national]		Kramer-LeBlanc (1999) [national]	
Minerals				
Calcium	Rush (1988d) [national] Endres (1981) [1 State] Edozien (1979) [national]		Kramer-LeBlanc (1999) [national]	
Iron	Rush (1988d) [national] Bailey (1983) [1 site] Endres (1981) [1 State] Edozien (1979) [national]	Kramer-LeBlanc (1999) [national]		
Magnesium	Rush (1988d) [national] Endres (1981) [1 State]		Kramer-LeBlanc (1999) [national]	
Phosphorus	Rush (1988d) [national] Edozien (1979) [national]		Kramer-LeBlanc (1999) [national]	
Zinc	Endres (1981) [1 State]		Kramer-LeBlanc (1999) [national]	
Other dietary components				
Cholesterol			Mardis (2000) [national] Kramer-LeBlanc (1999) [national]	
Fiber			Kramer-LeBlanc (1999) [national]	

See notes at end of table.

Continued—

Table 22—Findings from studies that examined the impact of the WIC program on the dietary intakes of pregnant women—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Sodium			Mardis (2000) [national] Kramer-LeBlanc (1999) [national]	
Added sugars		Kramer-LeBlanc (1999) [national]		

Note: Cell entries show the senior author's name, the publication date, and the scope of the study (for example, national vs. 1 city or 1 State). Where findings pertain only to a specific subgroup rather than the entire study population, the cell entry also identifies the subgroup {in brackets}.

Nonsignificant results are reported in the interest of providing a comprehensive picture of the body of research. As noted in chapter 1, a consistent pattern of nonsignificant findings may indicate a true underlying effect, even though no single study's results would be interpreted in that way. Readers are cautioned to avoid the practice of "vote counting," or adding up all the studies with particular results. Because of differences in research design and other considerations, findings from some studies merit more consideration than others. The text discusses methodological limitations and emphasizes findings from the strongest studies.

Findings for Mardis and Anand (2000) and Kramer-LeBlanc et al. (1999) are based on the same dataset. Both authors compared intakes of WIC participants and income-eligible nonparticipants in NHANES-III. The former compared means and the latter compared medians. Both authors also presented data for higher income nonparticipants.

Kramer-LeBlanc et al. (1999) also reported data for copper, potassium, retinol, pantothenic acid, selenium, and carotenes. With the exception of selenium (significant, with participants consuming less than nonparticipants) and carotenes (not significant, with participants consuming more than nonparticipants), all differences between participants and nonparticipants were nonsignificant, with participants consuming less than nonparticipants.

Findings reported for Rush et al. (1998d) are based on comparison of 24-hour mean intakes during late pregnancy, adjusted for baseline intake, for non-WIC participants and women who were WIC participants at entry into the study (181 women who moved from treatment to control groups over the course of the study were analyzed separately). Report also included results for analysis of intake from WIC foods, which were identical, except that vitamin A intake was also significant.

[1] Edozien (1979) reported no WIC effect for energy, vitamin A, and niacin, but point estimates are not provided. Text contradicts table in that text refers to significant impacts for vitamin A and niacin.

[2] For carbohydrates as a percentage of total energy intake. For intake in absolute gm, intake was lower among WIC participants, but the difference was not statistically significant.

not reported) and consumed greater total quantities of milk. Bailey et al. (1983) found that pregnant WIC participants ate fortified cereals, a major source of iron, more often than pregnant nonparticipants.

Results from early research do not permit an assessment of the potential impact of WIC on intake of folic acid. All of the available studies were completed before the recent widespread fortification of cereals and grain products with folic acid and before the increased attention to folic acid supplementation during pregnancy. Inadequate intake of folic acid has been associated with neural tube defects (Centers for Disease Control and Prevention (CDC), 1992).

Findings from the recent Kramer-LeBlanc et al. (1999) analysis of data from NHANES-III stand in stark contrast to the patterns described above. In that analysis, the only nutrient for which a significant difference was detected in median intakes of pregnant WIC participants and income-eligible nonparticipants was selenium. A comparison of the nutrient intakes of WIC participants and the maximum nutrient contribution of the WIC food package for pregnant women suggested that WIC participants may not have redeemed all of their vouchers or consumed all of the food provided.

As noted previously, the Kramer-LeBlanc et al. analysis was strictly descriptive and does not constitute a valid assessment of WIC impacts. Moreover, the analysis may have been hampered by small sample sizes (only 71 WIC participants). Nonetheless, the fact that findings from this study show virtually no overlap with findings from earlier studies raises a question about changes in the intakes of pregnant women over time. Consequently, positive findings from earlier studies cannot be assumed to apply to today's prenatal WIC participants.

Only one study (Mardis and Anand, 2000) assessed intakes of prenatal WIC participants and nonparticipants in relation to consumption patterns recommended in the *Dietary Guidelines for Americans*.[65] This analysis found no significant differences in intakes of total fat, saturated fat, cholesterol, or sodium. Moreover, with the exception of cholesterol, intakes of both participants and nonparticipants exceeded recommended levels. With regard to food intake, no significant differences were detected between WIC participants and nonparticipants in consumption of grains, vegetables, fruits, milk, or meats and beans.

[65]Kramer-LeBlanc et al. (1999) also report data for intake of total fat, saturated fat, cholesterol, and sodium, but it is the same data reported in Mardis and Anand (2000).

Given the increasing prevalence of pregnancy-associated obesity (Lederman et al., 2002) and the potential role of the WIC program in curtailing this problem, it is important to obtain valid estimates of WIC's impacts on women's dietary intakes based on more up-to-date information.

Nutritional Biochemistries

Five studies examined the impact of WIC participation on nutritional biochemistries of pregnant women. The most commonly examined outcomes were hemoglobin/hematocrit and the prevalence of anemia. The two national WIC studies looked at hemoglobin levels and reported conflicting results. The NWE (Rush et al., 1988d), which had a comparatively stronger research design, compared final hemoglobin measurements of pregnant women who were and were not participating in WIC. The analysis controlled for length of gestation and a number of other covariates and found no significant difference between the two groups. Edozien et al. (1979) compared hemoglobin levels for newly enrolling pregnant women and women who had been in WIC for less than 3 months and more than 3 months, adjusting for a number of covariates. The authors reported significant differences for both comparisons (women who had been enrolled in WIC for either length of time had significantly lower levels of anemia than newly enrolling pregnant women). This finding was not internally consistent with other measures of iron status included in the study, however, so it must be interpreted with caution.

Kennedy and Gershoff (1982) used multivariate regression techniques to compare final hemoglobin levels (generally measured at 34 weeks gestation or later) among WIC participants and nonparticipants, using the number of WIC vouchers received as the independent variable. The authors reported that WIC participation had a positive, significant effect on final hemoglobin levels.

Using a small sample of women in their 30th week of pregnancy (43 participants and 58 controls), Bailey et al. (1983) looked at biochemical indicators of iron, folate, and vitamin B_6 status. The authors found no significant difference between WIC participants and nonparticipants in mean hematocrit levels. They did find a positive, significant difference for transferrin saturation (a measure of iron status) and a significant, negative difference for serum folacin (a measure of folate status). The authors cautioned, however, that serum folate is very sensitive to short-term dietary intake (foods consumed shortly before the measure is taken) and is therefore not a good indicator of long-term nutriture or tissue stores of folate. The study also examined red blood cell folacin, a better measure of tissue stores, and found no significant difference between WIC participants and nonparticipants.

Finally, Metcoff and his colleagues (1985) examined 16 different nutritional biochemistries, assessing change between mid- and late pregnancy. After controlling for baseline values, the week of gestation at which the first measurements were taken, and the interval between measurements, the authors found no significant differences between pregnant women who were randomly assigned to WIC and non-WIC groups.

The relative paucity of research and the disparity in design and analytic techniques used in the studies that have been completed make it impossible to draw any firm conclusions about the impact of WIC participation on the nutritional biochemistries of pregnant women. The relationship may, indeed, be difficult to elucidate. As Rush et al. (1988d) pointed out, assessment of hemoglobin concentration, arguably the most straightforward and widely used measure of nutritional status among other population groups, is complicated during pregnancy by numerous physiologic processes that are not completely understood. Rush and his colleagues contended that adequate assessment of iron status during pregnancy requires the collection of several, more complex hematologic indices (transferrin saturation and serum iron) that are not readily available in most WIC or medical records.

Weight Gain During Pregnancy

Both of the national WIC evaluations (Edozien et al.,1979; Rush et al.,1988d) examined weight gain during pregnancy, which is known to be associated with adequate birthweight. Edozien et al. reported a positive impact, but Rush and his colleagues found no effect. A study completed in 1985 by Collins et al., as well as a stronger and more recent study by Roth et al. (2004) also found no effect.

Assessing the impact of WIC on weight gain during pregnancy may be subject to considerable measurement error. In order to gauge total weight gain, pre-pregnancy weight must be known, and in many cases, this is self-reported by the woman. If pre-pregnancy weights are not reliable, it is impossible to determine accurately how much weight was gained during pregnancy and to assess the relative adequacy of the weight gain. Widely accepted recommendations published by the IOM specify ranges of pregnancy weight gain and recommend that women who are underweight at the start of pregnancy gain somewhat more weight than the average woman and women who are overweight at the start of pregnancy gain somewhat less weight than the average (IOM, 1990). In most recent studies of WIC impacts, weight gain, if assessed at all, has been used as a covariate in analyses examining impacts on infant birthweight rather than as a main outcome.

Impacts of WIC Participation on Infants and Children

Although infants and children make up more than three-quarters of the total WIC population, very little research has been done on these participant groups until recently. In the late 1980s and early 1990s, FNS undertook a 5-year effort to design and field-test a longitudinal study of the short- and long-term impacts of WIC on infants and children. The University of North Carolina (UNC) and the Research Triangle Institute (RTI) completed a feasibility study in 1989 (Kotch et al., 1989) and a proposed a matched comparison group design. FNS had some concerns about the feasibility of creating adequately matched groups using State vital statistics data, however, and decided to conduct a field test of the proposed design and to develop and test an alternative design.

In 1989, Abt Associates Inc. and the Johns Hopkins University completed a field test of two alternative research designs—the original quasi-experimental design proposed by the UNC/RTI team as well as a modified experimental design (Puma et al., 1991). Researchers used experiences from the field test, including preliminary estimates of program impacts, to propose a design for a national evaluation of the impact of WIC on infants and children. FNS was in the process of reviewing proposals submitted by research organizations interested in implementing the project when Congress canceled the project.

Today, we still do not have solid answers to many of the questions the WIC Child Impact Study would have addressed. But a number of recent studies have begun to fill this critical information gap.

Research Overview

The literature search identified 41 studies that examined the relationship between WIC participation and nutrition and health outcomes of infants and children. Characteristics of these studies are summarized in table 23. The two national WIC evaluations are represented (Group I). Group II includes 16 studies that used

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Group I: National evaluations						
Rush et al. (1988c) (NWE)	Dietary intake, weight, height, head circumference, arm circumference and skinfold thickness, immunization status, use of preventive health care, behavior, vocabulary, and memory	Primary data collection in 174 WIC sites and 55 prenatal clinics (1983)	Random sample of infants and children ages 0-4 of women included in the longitudinal study of women (see Rush et al. (1988d) in table 17) (n=2,370)	Participant vs. nonparticipant	Participation dummy based on age of inception into WIC, including prenatally	Multivariate regression
Edozien et al. (1979)	Dietary intake, blood iron measures, height, weight, and head circumference	Primary data collection in 19 WIC sites in 14 States. Data collected at time of WIC enrollment and again after 6 and 11 months of participation (1973-76)	WIC infants and children ages 6-47 (n=16,000+)[3]	Participants, before vs. after	Participation dummy	Multivariate regression
Group II: Secondary analysis of national surveys						
Cole and Fox (2004)	Dietary intake, infant feeding practices, height, weight, variety of nutritional biochemistries, general health status, and dental health	1988-94 NHANES-III, usual intake	WIC and income-eligible children ages 1-4 (n=3,006)	Participant vs. nonparticipant	Participation dummy	Bivariate t-tests
Ponza et al. (2004)	Dietary intake	2002 FITS, usual intake	WIC and non-WIC infants and children ages 2-24 months (n=3,022)	Participant vs. nonparticipant	N/A	Comparison of means and proportions (no statistical tests reported)

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Siega-Riz et al. (2004)	Dietary intake	1994-96 and 1998 CSFII	WIC- and income-eligible children ages 2-5 who were not enrolled in school, in 2 income groups: <130% of poverty (n=1,772) and 130-185% of poverty (n=689)	Participant vs. nonparticipant	Participation dummy	Multivariate regression; investigated but did not implement correction for selection bias
Luman et al. (2003)	Immunization status	2000-01 NIS	WIC and non-WIC children ages 19-35 months (n=21,212)	Participant vs. nonparticipant	Participation dummy, with non-WIC children divided by income eligibility and prior WIC participation: Ineligible, eligible and participated in the past, and eligible but never participated	Multivariate regression
Shefer et al. (2001)	Immunization status	1999 NIS	WIC and non-WIC children ages 24-35 months (n=15,500)	Participant vs. nonparticipant	Participation dummy, with non-WIC children divided by income and prior WIC participation: previously on WIC, never on WIC and income-eligible, and never on WIC and not income-eligible	Bivariate t-tests[4]
Carlson and Senauer (2003)	Physician-reported general health status	1988-94 NHANES-III	Children ages 24-60 months (1) WIC sample: WIC and income-eligible (2) Full sample: WIC and non-WIC	Participant vs. nonparticipant	Participation dummy	Ordered probit equations

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Kranz and Siega-Riz (2002)	Added sugar intake	1994-96 CSFII	WIC and income-eligible children ages 2-5 (n=5,652)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Variyam (2002)	Dietary intake	1994-96 and 1998 CSFII	WIC and income-eligible children ages 1-4 (n=2,509)	Participant vs. nonparticipant	Participation dummy	Multivariate regression; quantile regressions
Burstein et al. (2000)	Dietary intake, height, weight, nutritional biochemistries, immunization status, general health status, dental health, use of preventive health care, and physical, emotional, and cognitive development	1988-94 NHANES-III 1993-95 SIPP 1995-97 CCDP	WIC and income-eligible children NHANES-III = 2,979 (12-59 months) SIPP = 1,302 (1-4 years) CCDP = 2,067 (2 years)	Participant vs. nonparticipant	Participation dummy	Bivariate t-tests
Kowaleski-Jones and Duncan (2000)	Motor skills, social skills, and temperament	NLSY, 1990-96 waves	(1) WIC and non-WIC infants and children (n=1,984)[5] (2) WIC and non-WIC infants and children with at least 1 other sibling born during the same period (n=453 sibling pairs)[5]	Participant vs. nonparticipant	Participation dummy	(1) Multivariate regression (2) Fixed-effects model

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Oliveira and Gundersen (2000)	Dietary intake	1994-96 CSFII	WIC and income-eligible children ages 1-4 in households where at least 1 other person also participated in WIC (n=180)	Participant vs. nonparticipant	Participation dummy	Multivariate regression[6]
Kramer-LeBlanc et al. (1999)	Dietary intake	1988-94 NHANES-III	WIC and income-eligible infants and children ages 2 months-4 years (n=6,636)	Participant vs. nonparticipant	Participation dummy	Bivariate t-tests
Rose et al. (1998)	Dietary intake	1989-91 CSFII	WIC and non-WIC children ages 1-4 who were not breastfeeding and resided in FSP-eligible households (n=499)	Participant vs. nonparticipant	Dose response: Value of monthly household per capita WIC benefit	Multivariate regression; investigated but did not implement adjustment for selection bias
Centers for Disease Control (1995)	Dietary intake, height, and weight	1988-91 NHANES-III	WIC and income-eligible infants and children ages 2-59 months (n=3,488)	Participant vs. nonparticipant	Participation dummy	Multivariate regression (height and weight) Comparison of means (dietary intake)
Rose et al. (1995)	Iron intake	1989-91 CSFII	WIC and non-WIC children ages 1-4 who were not breastfeeding (n=800)	Participant vs. nonparticipant	Participation dummy	Multivariate regression
Fraker et al. (1990)	Dietary intake	1985 CSFII	WIC and income-eligible children ages 1-4 (n=445)	Participant vs. nonparticipant	Dose response: Proportion of 4 recall days on which child was enrolled in WIC; also tested for combined WIC and FSP participation	Multivariate regression with selection-bias adjustment

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Group III: Secondary analysis of State-level files						
Lee et al. (2004a)	Number of dental visits per year and use of dental services (preventive, restorative, and emergency)	Longitudinal linked data base, including birth, Medicaid, WIC, and Area Resource files for children born in North Carolina in 1992 (1993-97)	WIC and non-WIC Medicaid recipients ages 1-4 (n=49,795)	Participant vs. nonparticipant	Dose-response: Number of months any WIC vouchers redeemed	Multivariate regression and ordered probit analysis, including 2-stage modeling to control for selection bias
Lee et al. (2004b)	Dental-care-related Medicaid costs	Longitudinal linked data base, including birth record, Medicaid, WIC, and Area Resource files for children born in North Carolina in 1992 (1992-96)	WIC and non-WIC Medicaid recipients ages 0-3 (n=49,795)	Participant vs. nonparticipant	Participation dummy (any participation per year)	Multivariate regression
Buescher et al. (2003)	Health care utilization and costs	Longitudinal linked data base, including birth, Medicaid, and WIC records for children born in North Carolina in 1992. Data base includes data through the 5th birthday (1992-97)	WIC and non-WIC Medicaid recipients ages 12-59 months (n=16,335-21,277 for 4 age-specific cohorts)	Participant vs. nonparticipant	Dose response: Cumulative WIC participation defined as none, high, medium, and low[7]	Multivariate regression; investigated but did not implement selection-bias-adjustment models
Lee et al. (2000)	Prevalence of anemia, failure to thrive, nutritional deficiencies, and use of preventive health care services	Longitudinal linked data base, including birth record, Medicaid, AFDC/TANF, FSP, and WIC files for all children born in Illinois from 1990 through 1996	WIC and non-WIC infants and children ages 0-59 months who received Medicaid benefits continuously	Participant vs. nonparticipant	Participation dummy	Multivariate regression and proportional hazards models[8]
Partington and Nitzke (1999)	Dietary intake	CSFII data for Midwest region (1994)[9]	WIC and income-eligible children ages 2-5 (n=183)	Participant vs. nonparticipant	Participation dummy	Bivariate z-tests

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Sherry et al. (2001)	Prevalence of anemia	PedNSS data for Colorado, New Mexico, Oklahoma, Utah, and Vermont (early 1980s-mid-1990s) (most data provided by WIC programs)	Infants and children ages 6-59 months (5,500-48,000 records per State per year)	Prevalence estimates for each State in 5-year intervals overall and by age, race/ethnicity, gender, birthweight, and type of screening visit	N/A	Trends analysis
Sherry et al. (1997)	Prevalence of anemia	PedNSS data for Vermont (1981-94) (most data provided by WIC programs)	Infants and children ages 6-59 months (n=12,000-19,500 records per year)	Prevalence estimates for each year for overall sample by age	N/A	Trends analysis
Yip et al. (1987)	Prevalence of anemia	(1) PedNSS data for Arizona, Kentucky, Louisiana, Montana, Oregon, and Tennessee (1975-85) (Most data provided by WIC programs) (2) Linked PedNSS and birth records for WIC participants in Tennessee PedNSS database (1975-84)	Infants and children ages 6-60 months (1) (n=499,759) (2) (n=72,983)	(1) Overall and age-specific prevalence estimates for each year: Initial measures vs. followup measures (2) Participant vs. nonparticipant	Participation dummy	(1) Linear regression; angular chi-square (2) Multivariate regression
USDA/FNS (1978)	Hemoglobin, hematocrit, height, and weight	WIC records in PedNSS data for Arizona, Kentucky, Tennessee, and Washington (1974-76)	WIC infants and children ages 0-59 months with 3 or more WIC visits at approximately 6-month intervals (n=5,692)[10]	Participants, before vs. after	Participation dummy	Chi-square tests

See notes at end of table. Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Group IV: Other State and local studies						
Black et al. (2004)	Height, weight, caregiver-perceived health status, and household food security	Primary data collection at urban medical centers in Washington, DC, Baltimore, Minneapolis, Boston, Little Rock, and Los Angeles (1998-2001)	WIC and income-eligible infants younger than 12 months (n=5,923)[11]	Participant vs. nonparticipant	Participation dummy, with non-WIC subjects divided into those who did not participate because of access issues and those who did not perceive a need for WIC	Multivariate regression
Kahn et al. (2002)	Prevalence of anemia	Medical records for 3 WIC sites in Chicago (1997-99)	WIC infants and children ages 6-59 months (n=7,053)	Participants, before vs. after	Participation dummy	Not well described
Shaheen et al. (2000)	Immunization status	Primary data collection (interviews and record abstractions) in a predominantly Hispanic low-income area of Los Angeles (dates not reported)	WIC and non-WIC children ages 2-4 (n=270)	Participant vs. nonparticipant	Participation dummy	Age-adjusted odds ratios
James (1998)	Immunization status	Medical records for 1 health care center in Mt. Vernon, NY	Randomly selected sample (matched on age and gender) of children who were up-to-date on immunizations at 12 months of age; equal size groups (n=150)	Participant vs. nonparticipant	Participation dummy	Chi-square tests

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Burstein et al. (1991)	Dietary intake, hemoglobin, hematocrit, height, weight, and head circumference	Primary data collection in Florida and North Carolina (1990-91)	Random sample of WIC and income-eligible infants (6 months old) stratified by birthweight (n=807)	Participant vs. nonparticipant	Participation dummy	Multivariate regression, including attempt to control for selection bias
Brown and Tieman (1986)	Dietary intake, hemoglobin, hematocrit, height, and weight	Primary data collection in low-income areas of 1 county in Minnesota (dates not reported)	WIC and income-eligible children ages 1-5 (n=52)	Participant vs. nonparticipant	Participation dummy	Chi-square test
Smith et al. (1986)	Hemoglobin	Medical records for 1 health center in Los Angeles; initial and 6-month followup measures	Subset of random sample of WIC and non-WIC children ages 1-4 who were diagnosed with anemia; matched on age, gender, and ethnicity (n=25 each group)	Participants vs. nonparticipants, before and after	Participation dummy	Analysis of variance
Miller et al. (1985)	Serum ferritin, hematocrit, and hemoglobin	Medical records for 1 child and youth clinic in Minneapolis (1973-74 and 1977)	WIC and income-eligible children ages 16-23 months (n~2,225)	Participants, before vs. after, separate groups	Participation dummy	Chi-square tests

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Vazquez-Seone et al. (1985)	Hemoglobin	Medical records for children enrolled in an inner-city health center in New Haven, CT, before and after initiation of WIC	WIC and income-eligible infants and children ages 9-36 months (n=583)	Participants, before vs. after, separate groups	Participation dummy	Bivariate t-tests
Hicks and Langham (1985)	IQ scores and school grades	Primary data collection and record abstractions in 3 counties in rural Louisiana (dates not reported)	Sibling WIC pairs ages 8-10; 1 "participated" in WIC prenatally and 1 enrolled after age 1 (n=19 sibling pairs)	Participant vs. sibling control	Participation dummy	Multivariate regression
Heimendinger et al. (1984)	Expected weight gain[12]	Medical records in 3 WIC and 4 non-WIC clinics in the same Boston neighborhoods (1974-79)	WIC- and Medicaid-eligible infants and toddlers up to 20 months with at least 2 height and weight measurements (n=1,907)	Participant vs. nonparticipant, ("value added"or expected growth vs. actual growth)	Participation dummy	Multivariate regression of "value-added" measures by age group (3-month intervals)
Paige (1983)	Medicaid costs and health care utilization	Medicaid records in 4 counties in Maryland, 2 in which WIC was available and 2 in which WIC was not available (1979-80)	WIC and income-eligible infants ages 0-11 months who were on Medicaid for at least 75% of study period (n=138)	Participant vs. nonparticipant	Participation dummy	Comparison of means and proportions (no statistical tests reported)
Hicks et al. (1982)	Hemoglobin, height, weight, and a variety of intellectual and behavioral measures	Primary data collection and record abstractions in 3 rural counties in Louisiana (dates not reported)	Sibling WIC pairs ages 6-8; 1 "participated" in WIC prenatally and 1 enrolled after age 1 (n=21 sibling pairs)	Participant vs. sibling control	Participation dummy	Multivariate regression

See notes at end of table.

Continued—

Table 23—Studies that examined the impact of the WIC program on nutrition and health outcomes of infants and children—Continued

Study	Outcome(s)	Data source[1]	Population (sample size)[2]	Design	Measure of participation	Analysis method
Weiler et al. (1979)	Hemoglobin	WIC records in 1 clinic in Fayette Co, KY (1976-77)	Infants ages 0-6 months initially certified for WIC because of anemia who had followup hemoglobin measure available (n=37)	Participants, before vs. after	Participation dummy	Bivariate t-tests

Note: N/A = Not applicable.

[1] Data sources:

CCDP = Comprehensive Child Development Programs.
CSFII = Continuing Survey of Food Intakes by Individuals.
FITS = Feeding Infants and Toddlers Study.
NHANES-III = Third National Health and Nutrition Examination Survey.
NIS = National Immunization Survey.
NLSY = National Longitudinal Survey of Youth.
PedNSS = Pediatric Nutrition Surveillance System.
SIPP = Survey of Income and Program Participation.

[2] Unless the description of the study sample indicates that a comparison group was limited to nonparticipants who were income-eligible for WIC or known to be Medicaid participants, all income levels were included in the comparison group. Income was generally controlled for in the analysis.

[3] Definition of comparison group varies for different outcomes. Children who never participated in WIC were main comparison group and were compared with former and/or current WIC participants.

[4] Also estimated a multivariate model of the relationship between intensity of WIC immunization activities and immunization coverage rates for WIC participants.

[5] Roughly half of the sample was assessed in the first year of life and half was assessed between their first and second birthdays.

[6] Authors also ran regression for full sample of WIC and income-eligible children. That model resulted in more significant effects.

[7] WIC participation defined based on percentage of months from age 1 through current age in which WIC vouchers had been redeemed. High = more than 66 percent, Medium = 34-66 percent, and Low = 33 percent or less.

[8] To control for the fact that several outcomes under study might be reasons for WIC enrollment, WIC participation was coded as zero if diagnosis of a particular problem preceded the date of WIC enrollment.

[9] CSFII data included two recalls per subject, but authors used only the first recall. Used only data for 1994 because, at the time the study was conducted, only that portion of the 1994-96 data set had been coded for food group consumption.

[10] Maximum sample; sample size varies for each outcome.

[11] Information on income was not collected. Receipt of private health insurance was used as a proxy for income, and the non-WIC sample was limited to infants without private insurance.

[12] A doctoral dissertation completed by Heimendinger in 1981 included data on height and weight-for-height. However, these data were dropped from the peer-reviewed journal article because of substantial problems with missing data.

data from national surveys. Group III includes nine studies that relied on State-level databases or, in one case, a regional database. These include WIC/Medicaid databases similar to those used in the previously summarized research on birth outcomes, State-level files from the Pediatric Nutrition Surveillance System (PedNSS),[66] and regional data from the Continuing Survey of Food Intakes by Individuals. Fourteen of the identified studies are other types of State and local studies (Group IV).

WIC research on infants and children is notably more recent than the previously summarized research on birth outcomes, breastfeeding, and the nutrition and health characteristics of pregnant women. Indeed, as shown in table 23, there have been several very recent contributions to this literature. Of the 41 identified studies, 10 are based on data collected primarily or exclusively in the early to mid-1990s, 10 are based on data collected in the mid- to late 1990s, and 3 used data that were collected exclusively in 2000 or later or had data collection periods that started late in the 1990s and extended beyond 2000. The relative recency of these studies is particularly important because of the increase in child participation experienced during the early 1990s. Studies based on data collected after this time are more likely to be generalizable to the current population of WIC children and are less subject to bias associated with restricted program access.

Although some studies included both infants (under 12 months of age) and children (1-4 years), the available research is heavily slanted toward children. Children were included in all but 4 of the identified studies, and 22 of the identified studies focused exclusively on children. Given that children make up 50 percent of the WIC population overall, this emphasis is not inappropriate (Bartlett et al., 2003).

A number of different outcomes have been examined, with the most common being dietary intake (17 studies), growth (12 studies), and anemia/iron status (16 studies). In addition, four studies looked at general health status, as perceived by caregivers or assessed by physicians, six studies focused on immunization status, and eight studies examined health or dental care use and/or costs. Finally, five studies looked at developmental outcomes, and two studies assessed impacts on household food sufficiency/security. Findings for each of these outcomes are summarized, in turn, in the sections that follow.

[66]PedNSS is a program-based nutrition monitoring system coordinated by the CDC. It includes State-reported data from programs that serve low-income infants and children. A majority of PedNSS data comes from WIC programs.

Research Results

Dietary Intake: Children

Table 24 summarizes findings from the 16 studies that examined the impact of WIC participation on the dietary intakes of children.[67] The table is divided into six sections: food energy and macronutrients, vitamins, minerals, other food components, food group servings, and summary measures of dietary quality. The text follows this general organization but discusses findings for vitamins and minerals and for food group intakes and summary measures in combined sections.

Most of the studies completed to date are subject to the methodological limitations that affect most existing FANP research on dietary intakes, as discussed in chapter 2 and in the preceding section on impacts among pregnant women. However, two very recent studies (Cole and Fox, 2004; Ponza et al., 2004) avoided these limitations. Both used the approach recommended by the IOM (2001) to estimate usual intakes of WIC participants and nonparticipants and, for nutrients with established EARs, used the recommended EAR-cutpoint method to estimate the percentage of children whose usual intakes were *adequate*. Cole and Fox (2004) explored the nutrient intakes of children ages 1-4, using data from NHANES-III.[68] Ponza and his colleagues used data from the Feeding and Infants and Toddlers Study (FITS), which included a national sample of infants and toddlers ages 4-24 months. Compared with national distributions, the FITS sample had slightly higher incomes, a smaller percentage of Hispanics, and a lower rate of WIC participation (Devaney et al., 2004; Ponza et al., 2004). Although neither of these studies was intended to provide valid estimates of the impact of WIC on dietary intakes—Cole and Fox (2004) used bivariate t-tests to assess differences between groups, and Ponza et al. (2004) did not test for statistical significance—findings are useful in providing an up-to-date perspective on the relative likelihood of adequate nutrient intakes among WIC participants and nonparticipants.

In reviewing findings, greatest weight is given to the study by Oliveira and Gundersen (2000), who analyzed data from the 1994-96 CSFII and employed a unique strategy to control for selection bias. To get around the fact that the CSFII does not include variables that provide suitable controls for selection bias,

[67]A total of 17 studies examined dietary intakes, but the study by Burstein et al. (1991) was limited to infants.

[68]Because NHANES-III collected a second day of dietary recall data for only 5 percent of respondents, the authors obtained the estimates of intraindividual variation needed to estimate usual intakes from the 1994-96 CSFII data.

Table 24—Findings from studies that examined the impact of the WIC program on the dietary intakes of children and/or infants

	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Food energy and macronutrients				
Food energy[1]	Cole (2004) [national] - C {2 years}	Cole (2004) [national] - C {3, 4 years} Ponza (2004) [national] - I+C Siega-Riz (2004) [national] - C Burstein (2000) [national] - C Kramer-LeBlanc (1999) [national] - I {2-3 months} Partington (1999) [1 region] - C Rose (1998) [national] - C Burstein (1991) [2 States] - I Fraker (1990) [national] - C Rush (1988c) [national] - I+C	Cole (2004) [national] - C {1 year} Oliveira (2000) [national] - C Kramer-LeBlanc (1999) [national] - I {4-11 months} + C {1-4 years} CDC (1995) [national] - B Brown (1986) [1 county] - C	
Protein	Rose (1998) [national] - C Edozien (1979) [national] - C Burstein (1991) [2 States] - I	Ponza (2004) [national] - I+C Burstein (2000) [national] - C Oliveira (2000) [national] - C Kramer-LeBlanc (1999) [national] - I+C Fraker (1990) [national] - C	Rush (1988c) [national] - C	Rush (1988c) [national] - I Edozien (1979) [national] - I
Fat	Kramer-LeBlanc (1999) [national] - I {4-11 months} Partington (1999) [1 region] - C	Siega-Riz (2004) [national] - C {130-185% poverty} Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-3 years} Rose (1998) [national] - C CDC (1995) [national] - B {Whites} Rush (1988c) [national] - I	Cole (2004) [national] - C Burstein (2000) [national] - C Kramer-LeBlanc (1999) [national] - C {4 years} CDC (1995) [national] - B {Blacks, Mexican-Americans}	Siega-Riz (2004) [national] - C {<130% poverty}
Saturated fat		Cole (2004) [national] - C Siega-Riz (2004) [national] - C {130-185% poverty} Kramer-LeBlanc (1999) [national] - I+C Rose (1998) [national] - C	Siega-Riz (2004) [national] - C {<130% poverty} Burstein (2000) [national] - C	

See notes at end of table.

Continued—

Table 24—Findings from studies that examined the impact of the WIC program on the dietary intakes of children and/or infants—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Carbohydrates	Siega-Riz (2004) [national] - C {<130% poverty}	Kramer-LeBlanc (1999) [national] - C {4 years} Rush (1988c) [national] - C	Siega-Riz (2004) [national] - C {130-185% poverty} Kramer-LeBlanc (1999) [national] - I {2-11 months} + C {1-3 years} Rush (1988c) [national] - I	
Vitamins				
Vitamin A	Edozien (1979) [national] - I+C	Ponza (2004) [national] - I Burstein (2000) [national] - C Oliveira (2000) [national] -C Kramer-LeBlanc (1999) [national] - I {2-11 months} + C {1-3 years} Rose (1998) [national] - C Burstein (1991) [2 States] - I Rush (1988c) [national] - C	Ponza (2004) [national] - C Kramer-LeBlanc (1999) [national] - C {4 years} Fraker (1990) [national] - C Rush (1988c) [national] - I Brown (1986) [1 county] - C	
Vitamin B_6	Oliveira (2000) [national] - C Rose (1998) [national] - C Fraker (1990) [national] -C Rush (1988c) [national] - C	Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-4 years} Rush (1988c) [national] - I	Kramer-LeBlanc (1999) [national] - I {4-11 months}	
Vitamin B_{12}		Kramer-LeBlanc (1999) [national] - C Rush (1988c) [national] - I+C	Kramer-LeBlanc (1999) [national] - I {2-3 months}	Kramer-LeBlanc (1999) [national] - I {4-11 months}
Vitamin C	Kramer-LeBlanc (1999) [national] - I {4-11 months} + C {1-3 years} Rush (1988c) [national] - I+C Edozien (1979) [national] - I+C	Cole (2004) [national] - C Ponza (2004) [national] - I+C Burstein (2000) [national] - C Oliveira (2000) [national] - C Kramer-LeBlanc (1999) [national] - I {2-3 months} Rose (1998) [national] - C Burstein (1991) [2 States] - I Fraker (1990) [national] - C Brown (1986) [1 county] - C	Kramer-LeBlanc (1999) [national] - C {4 years}	

See notes at end of table.

Continued—

Table 24—Findings from studies that examined the impact of the WIC program on the dietary intakes of children and/or infants—Continued				
	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Vitamin E	Rose (1998) [national] - C	Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-3 years} Fraker (1990) [national] - C	Kramer-LeBlanc (1999) [national] - C {4 years}	Kramer-LeBlanc (1990 [national] - I {4-11 months}
Folate	Burstein (2000) [national] - C Oliveira (2000) [national] - C Rose (1998) [national] - C Edozien (1979) [national] - I+C	Kramer-LeBlanc (1999) [national] - I {2-11 months} + C {1-3 years}	Kramer-LeBlanc (1999) [national] - C {4 years}	
Niacin	Kramer-LeBlanc (1999) [national] - I {4-11 months} Rose (1998) [national] - C Rush (1988c) [national] - C Edozien (1979) [national] - I+C	Kramer-LeBlanc (1999) [national] - I {2-3 months} Rush (1988c) [national] - I	Kramer-LeBlanc (1999) [national] - C	
Riboflavin	Rose (1998) [national] - C Edozien (1979) [national] - C	Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-4 years} Rush (1988c) [national] - C	Rush (1988c) [national] - I	Kramer-LeBlanc (1999) [national] - I {4-11 months} Edozien (1979) [national] - I
Thiamin	Kramer-LeBlanc (1999) [national] - I {2-3 months} Rose (1998) [national] - C Rush (1988c) [national] - C Edozien (1979) [national] - I+C	Kramer-LeBlanc (1999) [national] - I {4-11 months} + C {1-4 years} Rush (1988c) [national] - I		
Minerals				
Calcium	Cole (2004) [national] - C {2 years} Variyam (2002) [national] - C[2] Burstein (2000) [national] - C Edozien (1979) [national] - C	Cole (2004) [national] - C {1, 3, 4 years} Ponza (2004) [national] - I+C Siega-Riz (2004) [national] - C Oliveira (2000) [national] - C Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-4 years} Rose (1998) [national] - C Burstein (1991) [2 States] – I[3] Fraker (1990) [national] - C CDC (1995) [national] - B {Blacks}[4] Rush (1988c) [national] - C	CDC (1995) [national] - B {Whites, Mexican-Americans} Brown (1986) [1 county] - C	Kramer-LeBlanc (1999) [national] - I {4-11 months} Rush (1988c) [national] - I Edozien (1979) [national] - I

See notes at end of table.

Continued—

Table 24—Findings from studies that examined the impact of the WIC program on the dietary intakes of children and/or infants—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Iron	Variyam (2002) [national] - C Siega-Riz (2004) [national] - C Oliveira (2000) [national] - C Kramer-LeBlanc (1999) [national] - I {4-11 months} + C {1-3 years} Rose (1998) [national] - C Rose (1995) [national] - C Burstein (1991) [2 States] - I Rush (1988c) [national] - I+C Brown (1986) [1 county] - C Edozien (1979) [national] - I+C	Cole (2004) [national] - C Ponza (2004) [national] - I+C Burstein (2000) [national] - C Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {4 years} Fraker (1990) [national] - C		
Magnesium	Rose (1998) [national] - C	Kramer-LeBlanc (1999) [national] - C {1-3 years} Rush (1988c) [national] - C	Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {4 years}	Rush (1988c) [national] - I Kramer-LeBlanc (1999) [national] - I {4-11 months}
Phosphorus	Edozien (1979) [national] - C	Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-3 years} Rose (1998) [national] - C	Kramer-LeBlanc (1999) [national] - C {4 years}	Kramer-LeBlanc (1999) [national] - I {4-11 months} Rush (1988c) [national] - I+C Edozien (1979) [national] - I
Zinc	Variyam (2002) [national] - C[5] Rose (1998) [national] - C	Cole (2004) [national] - C Fraker (1990) [national] - C	Oliveira (2000) [national] - C Kramer-LeBlanc (1999) [national] - I+C	
Other dietary components				
Cholesterol	Cole (2004) [national] - C {2 years}	Cole (2004) [national] - C {3, 4 years} Burstein (2000) [national] - C Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-3 years}	Kramer-LeBlanc (1999) [national] - C {4 years} Rose (1998) [national] - C	Kramer-LeBlanc (1999) [national] - I {4-11 months}
Fiber	Cole (2004) [national] - C {2 years}	Cole (2004) [national] - C {3 years} Siega-Riz (2004) [national] - C {<130% poverty}	Siega-Riz (2004) [national] - C {130-185% poverty} Kramer-LeBlanc (1999) [national] - I+C	Cole (2004) [national] - C {4 years}

See notes at end of table.

Continued—

Table 24—Findings from studies that examined the impact of the WIC program on the dietary intakes of children and/or infants—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants consumed more	Participants consumed more/same	Participants consumed less	Participants consumed less
Sodium	Cole (2004) [national] - C {2 years}	Cole (2004) [national] - C {3 years} Burstein (2000) [national] - C	Cole (2004) [national] - C {4 years} Kramer-LeBlanc (1999) [national] - I {2-3 months} + C {1-4 years}	Kramer-LeBlanc (1999) [national] - I {4-11 months}
Added sugar		Kramer-LeBlanc (1999) [national] - C {4 years}	Kramer-LeBlanc (1999) [national] - I { 2-11 months} + C {1-3 years} Partington (1999) [1 region] - C	Siega-Riz (2004) [national] - C Kranz (2002) [national] - C
Food group servings				
Dairy	Burstein (2000) [10 sites] - C Partington (1999) [1 region] - C	Cole (2004) [national] - C		
Fruit	Cole (2004) [national] - C {3 years}	Cole (2004) [national] - C {2, 4 years} Siega-Riz (2004) [national] - C	Burstein (2000) [10 sites] - C Partington (1999) [1 region] - C	
Fruit juice	Burstein (2000) [10 sites] - C			
Fruit and vegetables	Siega-Riz (2004) [national] - C		Burstein (2000) [10 sites] - C	
Grains		Cole (2004) [national] - C Partington (1999) [1 region] - C		
Meat/bean		Cole (2004) [national] - C	Partington (1999) [1 region] - C	
Vegetables	Partington (1999) [1 region] - C {“other”vegs}[6]	Burstein (2000) [10 sites] - C	Cole (2004) [national] - C Partington (1999) [1 region] - C {total vegs}	

See notes at end of table.

Continued—

Table 24—Findings from studies that examined the impact of the WIC program on the dietary intakes of children and/or infants—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants scored higher	Participants scored higher/same	Participants scored lower	Participants scored lower
Summary measures				
Total HEI score		Cole (2004) [national] - C		

Notes: Cell entries show the senior author's name, the publication date, the scope of the study (for example, national vs. 1 city or 1 State), and the participant group(s) involved: (B = both infants and children, C = children, and I = infants). Where findings pertain only to a specific subgroup rather than the entire study population, the cell entry also identifies the subgroup {in brackets}.

Nonsignificant results are reported in the interest of providing a comprehensive picture of the body of research. As noted in chapter 1, a consistent pattern of nonsignificant findings may indicate a true underlying effect, even though no single study's results would be interpreted in that way. Readers are cautioned to avoid the practice of "vote counting," or adding up all the studies with particular results. Because of differences in research design and other considerations, findings from some studies merit more consideration than others. The text discusses methodological limitations and emphasizes findings from the strongest studies.

Data for Cole (2004) and Ponza (2004) reflect *usual* intakes, estimated using methods recommended by the IOM (2001). For nutrients with established EARs (vitamins A and C, iron, and protein (Ponza, 2004, only)), both studies estimated the *prevalence of adequate usual intakes* using the methods recommended by the IOM (2001). For these nutrients, findings are reported relative to the prevalence of adequate usual intakes. Thus, "participants consumed more" indicates that, relative to nonparticipants, participants had a *greater prevalence of adequate usual intakes* and "participants consumed less" means that participants had a *lower prevalence of adequate usual intakes*.

Ponza (2004) did not test the statistical significance of differences between groups.

Findings reported for Siega-Riz (2004) are for total intakes. A separate snacks-only analysis revealed significant differences for the <130% of poverty group for added sugars (participants consumed less) and iron (participants consumed more). For the 130-185% of poverty group, only the difference in intake of added sugars was significant (participants consumed less).

Findings reported for Variyam (2002) are based on OLS regression model. Variations observed in the quantile regressions, if any, are described in footnotes.

Kramer-LeBlanc (1999) also reported significant differences between WIC participant and nonparticipant infants ages 4-11 months for vitamin D, total carotenes, copper, selenium, and potassium. For the first two, intakes were greater among WIC participants. For the latter three, the observed effect was in the opposite direction.

Findings reported for Burstein et al. (1991) are based on selection-bias-adjusted model. The authors cautioned that both the single-equation model and instrumental variables model produced implausible results.

Findings reported for Rush (1988c) are based on comparison of current WIC participants with children who never participated in WIC and reflect results for analyses that compared 24-hour intakes.

[1] Edozien (1979) reported no significant between-group differences in energy intakes of either infants or children, but did not report point estimates.

[2] In quantile analysis, difference was statistically significant at all quantiles except 0.9.

[3] Based on main analysis, which assessed the percentage of infants with intakes below 77 percent of the RDA. Supplementary analysis that examined mean intakes found that WIC infants consumed less calcium than non-WIC infants.

[4] Reported finding is for calcium per 1,000 kilocalories. For total calcium in gm, mean was lower for WIC participants.

[5] In quantile analysis, difference was statistically significant at the 0.75 quantile only.

[6] Excludes deep-yellow and dark-green vegetables, as well as legumes, white potatoes, and other starchy vegetables.

as reported by previous researchers (Fraker, 1990), Oliveira and Gundersen limited their analysis sample to WIC participants and low-income nonparticipants who lived in households where at least one other member was on the WIC program. The rationale for this restriction was that it effectively controlled for key sources of selection bias, including lack of awareness of the WIC program and resistance to participation because of stigma or other reasons. The authors acknowledge that two important sources of potential bias remain, both of which are associated with rationing rather than self-selection. The income-eligible nonparticipant group may have included (1) children who were not actually eligible for WIC because they did not have a certified nutritional risk and (2) children who were fully eligible but could not participate because the local WIC program had no available slots. Both of these sources of bias would tend to underestimate program impacts.

A downside to the approach used by Oliveira and Gundersen is that it severely limited sample sizes. The final analysis sample included only 180 children, whereas the full 1994-96 CSFII database included 1,206 children who were either enrolled in WIC or were income-eligible. The small sample size means that the analysis was likely able to detect only large differences. This limitation, in combination with the remaining sources of selection bias, means that the study provides a fairly conservative estimate of WIC's effects.

Another limitation to the Oliveira and Gundersen study is that it examined a relatively limited set of nutrients. For most nutrients not examined by Oliveira and Gundersen, the strongest available evidence comes from a study completed by Rose, Habicht, and Devaney (1998), who used data from the 1989-91 round of the CSFII. This study may overstate WIC impacts, however, because the authors did not control for selection bias (they report that they "found no evidence of it") and limited their sample to children in FSP-eligible households (household incomes below 130 percent of poverty). This sample represents the lower end of the income distribution of WIC participants and children in this group may benefit from WIC's supplemental food benefit more than higher income children would.

Food Energy and Macronutrients. The evidence suggests that WIC participation does not affect children's intakes of food energy. Although WIC participants tend to have greater energy intakes than nonparticipants, these differences tend not to be statistically significant. Only Cole and Fox (2004) reported a significant difference (based on bivariate t-tests), and it was limited to 2-year-olds.

Results for protein are equivocal. Oliveira and Gundersen (2000) found no significant difference in intakes of participants and nonparticipants. However, the earlier study by Rose, Habicht, and Devaney (1998) found that WIC participants consumed significantly more protein than nonparticipants. It is possible that the effect on protein intake may be small (and therefore not detected by Oliveira and Gundersen) and limited to the lowest income participants.

Relatively few studies have examined intakes of fat, saturated fat, and carbohydrates, and Oliveira and Gundersen (2000) is not among them. Consequently, the best available data in this area comes from a study by Siega-Riz et al. (2004). Siega-Riz and her colleagues used the 1994-96, 1998 CSFII dataset to assess intakes of children who were not enrolled in school and who had household incomes below 185 percent of poverty. The authors did not attempt to control for selection bias, acknowledging the limitations of the CSFII data. To provide a somewhat greater level of control for unmeasured differences between groups, they completed separate analyses for children with incomes below 130 percent of poverty and children with incomes between 130 percent and 185 percent of poverty. They also included a sizable number of covariates in their models, including variables that controlled for mother's age, television viewing, use of dietary supplements, presence of dietary restrictions, and enrollment in child care.

The analysis revealed no significant differences in intakes of fat, saturated fat, or carbohydrates (expressed as a percentage of total energy intake) between WIC participants and nonparticipants with household incomes between 130 and 185 percent of poverty. However, among lower income children—those residing in households with incomes below 130 percent of poverty—WIC participants consumed significantly less fat and significantly more carbohydrates than nonparticipants. These suggestive findings would be more convincing if they were replicated in the restricted sample analyzed by Oliveira and Gundersen.

Vitamins and Minerals. Giving precedence to Oliveira and Gundersen, there is strong evidence that WIC participation increases children's intakes of vitamin B_6, folate, and iron. The evidence that WIC increases children's iron intake is particularly strong. Almost all of the identified studies assessed iron intake, and all but one of the studies that used multivariate analysis techniques found significantly greater intakes among WIC children. Consistent results for Oliveira and Gundersen (2000) and Rose, Devaney, and Habicht (1998) also strongly suggest that WIC participation does not significantly affect children's intakes of vitamin A, vitamin C, or calcium.

For other vitamins and minerals, evidence of a significant WIC impact is less clear. Rose, Habicht, and Devaney (1998) reported a significant impact on children's intake of zinc, while Oliveira and Gundersen found no such effect. Rose, Habicht, and Devaney also reported significant impacts for several nutrients that were not included in the Oliveira and Gundersen study, including vitamin E, niacin, riboflavin, thiamin, and magnesium. In all cases, mean intakes were greater for WIC participants than for nonparticipants. These findings suggest a WIC impact among the lowest income children but would be more convincing if they were replicated in the restricted sample used by Oliveira and Gundersen.

As noted previously, increased nutrient intake by participants does not necessarily mean that participants are more likely than nonparticipants to have adequate diets. Recent data on usual nutrient intakes of age-eligible children indicate that the vast majority of both WIC and non-WIC children have nutritionally adequate diets. Cole and Fox (2004) found that virtually all children ages 1-4, regardless of WIC participation status, had adequate usual intakes of iron and zinc. Ponza et al. (2004) reported similar findings for iron for children ages 1 and 2.[69]

Neither Cole and Fox nor Ponza et al. assessed intakes of vitamin B_6 or folate (the other two nutrients found to be significant in Oliveira's and Gundersen's analysis). However, findings from the main FITS analysis, which did not differentiate children by WIC participation status, showed that less than 1 percent of all 1- and 2-year-olds had inadequate usual intakes of vitamin B_6, and only 2 percent had inadequate usual intakes of folate (Devaney et al., 2004). The main FITS analysis also provides information on the other nutrients for which Rose, Habicht, and Devaney (1998) reported a significant WIC impact. FITS found that less than 1 percent of children ages 1 and 2 had inadequate usual intakes of riboflavin, thiamin, or magnesium, 3 percent had inadequate usual intakes of niacin, and 58 percent had inadequate usual intakes of vitamin E. The authors urged caution in interpreting the finding for vitamin E, given that clinical data from NHANES-III do not indicate problems with vitamin E status. They suggested that the high prevalence of apparently inadequate vitamin E intakes may be associated with the difficulty of assessing the types and amounts of fats and oils used in cooking and/or with variability in food composition databases.

Data from Cole and Fox (2004), Devaney et al. (2004), and Ponza et al. (2004) suggest that the prevalence of inadequate nutrient intakes among very young children is low, and that today's WIC children are doing as well nutritionally as their nonparticipating counterparts. However, the fact that the descriptive analyses completed by Cole and Fox (2004a) and Ponza et al. (2004) did not reveal meaningful differences in the prevalence of nutrient inadequacy among WIC and non WIC children does not necessarily mean that the WIC program has no impact on children's diets. It may be, for example, that WIC is responsible for bringing intakes of participating children up to the level of other children. The question of WIC impacts cannot be assessed even at a basic level without multivariate analysis techniques that, at a minimum, control for measured differences between the two groups.

Other Dietary Components. Information on the impact of WIC on other dietary components, including cholesterol, sodium, fiber, and added sugars, is very limited. The majority of studies that looked at these components were descriptive studies that assessed differences between groups with bivariate t-tests or did not assess statistical significance.

There is no convincing evidence that WIC participation influences children's intakes of cholesterol, sodium, or fiber. There is suggestive evidence, however, that WIC participation decreases children's consumption of added sugar. Using data from the most recent CSFII, Siega-Riz et al. (2004) and Kranz and Siega-Riz (2002) both found that WIC children consumed significantly less added sugar than non-WIC children. In the Siega-Riz et al. study, this difference was assessed based on the percentage of food energy provided by added sugar and was significant for two different income samples (<130 percent of poverty and 130-185 percent of poverty). In the Kranz and Siega-Riz study, the outcome measure was teaspoons of sugar per 100 kilocalories and the difference was also

[69]As discussed later in this chapter, the adequacy of children's iron intakes is consistent with declining levels of anemia in this population and may reflect an indirect effect of the WIC program on the availability and use of iron-fortified breakfast cereals.

observed for two different income groups (<130 percent of poverty and ≤185 percent of poverty). While suggestive of a positive WIC effect, the evidence would be more convincing if it were replicated in the restricted sample used by Oliveira and Gundersen (2000).

Food Group Intake and Summary Measures of Dietary Quality. Data on the impact of WIC participation on children's food intake or on overall dietary quality are also very limited. Most of the studies that looked at these outcomes used simple bivariate t-tests. And, as table 24 clearly illustrates, the overlap in significant findings across studies is small. The available data are too limited to support even tentative conclusions about WIC impacts in these areas.

Dietary Intake: Infants

Five of the identified studies reported separate estimates of WIC's impact on the dietary intake of WIC and non-WIC infants (table 23). This includes both national WIC evaluations (Rush et al., 1988c; Edozien et al., 1979), the field test of the WIC Child Impact Study (Burstein et al., 1991), and the more recent descriptive studies completed by Kramer LeBlanc et al. (1999) and Ponza et al. (2004). Cole and Fox (2004) looked at reported infant feeding patterns of WIC and non WIC infants but did not examine dietary intake per se.

Of the available studies, the strongest are the field test of the WIC Child Impact Study (Burstein et al., 1991) and the NWE (Rush et al., 1988c), although both have methodological limitations. As shown in table 24, both the NEW and the field test of the WIC Child Impact Study found that WIC infants had significantly higher intakes of iron than non-WIC infants. Ponza et al.'s (2004) recent assessment of usual nutrient intakes found that WIC infants ages 7-11 months had greater mean usual intakes of iron than did nonparticipant infants and, more importantly, that the prevalence of adequate usual iron intakes was greater for WIC infants than for non-WIC infants (99 percent vs. 90 percent). The statistical significance of these differences was not tested.

The NWE also found that WIC infants consumed significantly less calcium, magnesium, and phosphorus than non-WIC infants. Burstein and her colleagues (1991) reported no impact on calcium in their main analysis, which assessed the percentage of infants consuming less than 77 percent of the RDA; however, supplementary analyses that used mean intakes found, like Rush et al., that WIC infants consumed significantly less calcium than non-WIC infants.

For the NWE, Rush and his colleagues completed a detailed analysis of the sources of nutrients in infants' diets and found that the greater iron intakes and lower calcium, magnesium, and phosphorus intakes noted for WIC infants were related. All of these findings were associated with an increased use of cows' milk among non-WIC infants. Because the American Academy of Pediatrics recommends that cow's milk not be fed to infants younger than 12 months, the lower intakes of calcium, magnesium, and phosphorus among WIC infants were not interpreted as negative impacts. Burstein and her colleagues found a similar pattern. Specifically, they found that, among nonbreastfed infants, WIC infants were more likely to receive formula and non-WIC infants were more likely to receive cow's milk. Moreover, among formula-fed infants, WIC infants were more likely to receive iron-fortified formula and non-WIC infants were more likely to receive formula that was not fortified with iron.

Recent descriptive studies provide some evidence that differences between WIC infants and non-WIC infants in the use of cow's milk may persist today. For example, Kramer-LeBlanc and her colleagues (1999) found that, among infants ages 4-11 months, WIC participants consumed significantly less protein, calcium, magnesium, riboflavin, vitamin B_{12}, and sodium. All of these nutrients occur in greater concentrations in cow's milk than in iron-fortified infant formula. In addition, Cole and Fox (2004) analyzed the infant feeding inventory in NHANES-III and found that WIC participants were significantly less likely than nonparticipants to be fed cow's milk before 12 months of age.

In an analysis of 24-hour intakes, Ponza et al. (2004) found no significant difference between WIC infants and non-WIC infants in the percentage consuming cow's milk. In addition, findings from an inventory of feeding practices that assessed whether an infant had ever been fed cow's milk found no difference between WIC and non-WIC infants ages 7-11 months. Reported feeding of cow's milk was rare among younger infants (4-6 months). In this age group, however, significantly more WIC infants than non-WIC infants had been fed cow's milk at some point. These results should be interpreted with caution because the comparison group used in Ponza et al.'s analysis included all income levels, which may obscure differences between WIC participants and income-eligible nonparticipants, who constitute a more appropriate comparison group.

Burstein and her colleagues (1991) also found that WIC participation was associated with more appropriate introduction of solid foods. WIC infant feeding guidelines, which are based on recommendations of the American Academy of Pediatrics and other expert groups, recommend that no solids be introduced until infants are at least 4 months of age. Indeed, the WIC food package for infants younger than 4 months is limited to iron-fortified formula (USDA/FNS, 2003c). Burstein and her colleagues found that nonparticipant infants were significantly more likely than WIC infants to be fed solid foods before 4 months of age.

It is not clear whether this finding still holds for today's WIC infants. Based on the infant feeding inventory in NHANES-III, Cole and Fox (2004) found no difference between WIC participants and nonparticipants in the percentage of infants or children who were fed solid foods before 4 months of age. Similarly, Ponza and his colleagues (2004) found no differences between WIC participants and nonparticipants in the mean ages at which infant cereal and pureed baby foods were introduced. These data may be less reliable than the data from the Burstein et al. study, however, because they are based on a more extended recall period.[70] In addition, as noted previously, the all-income comparison group used by Ponza and his colleagues may obscure differences between WIC participants and income-eligible nonparticipants.

Kramer-LeBlanc et al. (1999) found that carbohydrate and fiber intakes among infants 4-11 months were significantly lower for WIC participants than for income-eligible nonparticipants and suggested that this pattern may be associated with earlier introduction and greater consumption of cereal among non-WIC infants. Data from Ponza et al., suggest that the difference in cereal consumption may be concentrated among older infants and, therefore, not associated with better adherence to infant feeding guidelines, per se. Ponza and his colleagues found no difference between WIC participants and nonparticipants in consumption of either infant cereal or ready-to-eat cereal among infants ages 4-6 months. Among infants ages 7-11 months, however, the percentage consuming ready-to-eat cereal was 77 percent lower for WIC participants than for nonparticipants.

Growth

A total of 12 studies attempted to measure the impact of WIC on the growth of infants and children (table 23). Findings from these studies are summarized in table 25. Note that the far-left column of the table, labeled "Participants higher," includes findings that can be considered both positive and negative. For example, greater height or length-for-age among WIC participants would generally be considered a positive finding, while a greater prevalence of overweight would be considered a negative finding.

Many of the earliest efforts to assess WIC's impact on children's growth were hampered by technical difficulties such as missing or inaccurate data in medical records or WIC files (Heimendinger et al., 1984; USDA/FNS, 1978) and problems with equipment calibration (Burstein et al., 1991). Self-selection issues have also affected this research. In the NWE, Rush and his colleagues (1988d) reported differential recruitment of children with abnormal growth (overweight, underweight, or stunted) into WIC, in keeping with the program's focus on individuals with identifiable nutritional risks. This pattern of self selection is likely the reason for the significantly greater prevalence of underweight and growth retardation among WIC children reported by Cole and Fox (2004) and Burstein et al. (2000) in their more recent descriptive analyses of NHANES-III data.

In the 1991 field test of the WIC Child Impact Study, Burstein and her colleagues (1991) explicitly attempted to control for selection bias. In their final report, however, they present results from both the single-equation models and the instrumental-variables models because there was some concern about the performance of both models. As shown in table 25, the instrumental-variables model found that WIC and a significant *negative* effect on infants' length-for-age. The single-equation model found that WIC participation had a significant and negative effect on head circumfrence.

Heimendinger et al. (1984) attempted to compensate for problems of self selection as well as the potential for regression to the mean in a longitudinal data set by determining the expected rate of growth and comparing "value added" measures for WIC and non WIC children who had at least two weight and height measurements. She demonstrated a positive WIC effect on

[70]The Burstein, et al. (1991) study was limited to 6-month-old infants, so caregivers reported on relatively recent feeding practices. The NHANES-III infant feeding histories analyzed by Cole and Fox (2004) included infants up to 12 months.

Table 25—Findings from studies that examined the impact of the WIC program on other nutrition, health, and developmental outcomes of infants and/or children

Outcome	Significant impact: Participants higher	No significant impact: Participants higher/same	No significant impact: Participants lower	Significant impact: Participants lower
Growth				
Expected weight gain	Heimendinger (1981) [3 areas in 1 State] - B			
Height/length	Black (2004) [6 cities] {compared with no WIC due to access problems} - I Edozien (1979) [national] - B Hicks (1982) [3 counties] - C	Brown (1986) [county] - C	Rush (1988c) [national] - I	Black (2004) [6 cities] {compared with no WIC due to no need} - I Burstein (1991) [2 States] - I[1] Rush (1988c) [national] - C
Weight	Edozien (1979) [national] - B[2]	Rush (1988c) [national] - I Hicks (1982) [3 counties] - C	Rush (1988c) [national] - C	
Prevalence/ likelihood of underweight[3]	Cole (2004) [national] - C Burstein (2000) [national] - C	Burstein (1991) [2 States] - I	Black (2004) [6 cities] compared with no WIC due to no need} - I	Black (2004) [6 cities] {compared with no WIC due to access problems} - I
Prevalence of failure to thrive				Lee (2000) [1State] - B
Prevalence of growth retarda-tion/stunting		Cole (2004) {national} - C		
Head circumference	Edozien (1979) [national] {enrolled within 1 month of birth} - I	Rush (1988c) [national] - B	Burstein (1991) [2 States] - I	
Prevalence/ likelihood of overweight[3]		Black (2004) [6 cities] - I CDC (1995) [national] - B {Blacks, Whites} Burstein (1991) [2 States] - I Rush (1988c) [national] - B[4]	Cole (2004) [national] - C Burstein (2000) [national] - C CDC (1995) [national] - B {Mexican-Americans}	
Measures of iron status				
Mean hematocrit/ hemoglobin or other measure	Miller (1995) [1 site] - C Smith (1986) [1 site] - B Vazquez-Seone (1985) [1 site] - B Edozien (1979) [national] - B Weiler (1979) [1 site] - I USDA/FNS (1978) [4 States] - B	Brown (1986) [county] - C[5]		

See notes at end of table.

Continued—

Table 25—Findings from studies that examined the impact of the WIC program on other nutrition, health, and developmental outcomes of infants and/or children—Continued

	Significant impact	No significant impact		Significant impact
Outcome	Participants higher	Participants higher/same	Participants lower	Participants lower
Prevalence/ likelihood of anemia		Burstein (2000) [national] - C Lee (2000) [1 State] - B	Cole (2004) [national] - C Kahn (2002) [3 sites] - B Hicks (1982) [3 counties] - C	Sherry (2001) [national] - B Sherry (1997) [national] - B Burstein (1991) [2 States] – I[6] Yip (1987) [national] – B[7] Vazquez-Seone (1985) [1 site] - B Edozien (1979) [national] - B USDA/FNS (1978) [4 States] - B
Prevalence of iron deficiency anemia				Cole (2004) [national] - C
Other measures of nutrition/health/development				
Health status - caregiver-reported	Black (2004) [6 cities] {compared with no WIC due to access problems} - I		Cole (2004) [national] - C {2-4 years} Black (2004) [6 cities] {compared with no WIC due to no need} - I	Cole (2004) [national] - B {infants and 1 year}
Health status - physician assessed	Cole (2004) [national] - C {4 years} Carlson (2000) [national] - C	Cole (2004) [national] - C {1 and 2 years}	Cole (2004) [national] - B {infants and 3 years} Burstein (2000) [national] - C	
Immunization status	Luman (2003) [national] - C Shefer (2001) [national] - C Burstein (2000) [10 sites] - C {all others} Rush (1988) [national] -C	Burstein (2000) [10 sites] - C {MMR} Shaheen (2000) [1 city] - C James (1998) [1 site] - C		
Dental health status	Cole (2004) [national] - C	Burstein (2000) [national] - C		
Utilization of health care or dental care services	Cole (2004) [national] - C {ever} Lee (2004a) [1 State] - C Buescher (2003) [1 State] - C Lee (2000) [1 State] - B	Cole (2004) [national] - C {past year} Burstein (2000) [national] - C Rush (1988) [national] - B Paige (1983) [1 State] - I		Lee (2004a) [1 State] - C {emergency visits}[8]

See notes at end of table.

Continued—

Table 25—Findings from studies that examined the impact of the WIC program on other nutrition, health, and developmental outcomes of infants and/or children—Continued

Outcome	Significant impact: Participants higher	No significant impact: Participants higher	No significant impact: Participants lower	Significant impact: Participants lower
Health care/dental care costs	Buescher (2003) [1 State] - C	Paige (1983) [1 State] - I Lee (2004b) [1 State] - B {age 3}	Lee (2004b) [1 State] - B {age 2}	Lee (2004b) [1 State] - B {ages 0-1}
Household food security		Black (2004) [6 cities] {WIC compared with no WIC due to access problems} - I	Burstein (2000) [all samples] - C	Black (2004) [6 cities] {WIC compared with no WIC due to no need} - I
Developmental outcomes	Rush (1988) [national] - C Hicks (1982) [1 site] - C Hicks (1985) [1 site] - C		Kowaleski-Jones (2000) [national] - C {motor and social skills}	Kowaleski-Jones (2000) [national] - C[8] {difficult temperament}

Notes: Cell entries show the senior author's name, the publication date, the scope of the study (for example, national vs. 1 city or 1 State), and the participant group(s) involved: (B = both infants and children, C = children, and I = infants). Where findings pertain only to a specific subgroup rather than the entire study population, the cell entry also identifies the subgroup {in brackets}.

Nonsignificant results are reported in the interest of providing a comprehensive picture of the body of research. As noted in chapter 1, a consistent pattern of nonsignificant findings may indicate a true underlying effect, even though no single study's results would be interpreted in that way. Readers are cautioned to avoid the practice of "vote counting," or adding up all the studies with particular results. Because of differences in research design and other considerations, findings from some studies merit more consideration than others. The text discusses methodological limitations and emphasizes findings from the strongest studies.

Findings reported for Lee (2004b) reflect results for total dental-care-related Medicaid costs. Separate analysis that examined likelihood of having *any* dental-care-related Medicaid costs showed that WIC participants were more likely than nonparticipants to have dental care costs during infancy (up to 12 months) and as 1- and 2-year-old participants. Difference for3-year-olds was comparable in direction, but not statistically significant.

Findings reported for Kowaleski-Jones and Duncan (2000) are based on a fixed-effects model that also controlled for prenatal FSP participation.

Findings for Burstein (1991) are based on the selection-adjusted model. The authors cautioned that both the single-equation model and the selection-adjusted model produced implausible results.

Paige (1983) did not test the statistical significance of between-group differences.

The USDA/FNS (1978) study found substantial decreases in the number of infants and children who were considered low length/height-for-age or low weight-for-height and a substantial increase in the number considered high weight for height. The authors concluded, however, that these apparent changes, which were largely limited to differences between initial and first followup visits were attributable to errors in initial measurements rather than WIC participation.

[1] Single-equation model found no significant difference between groups in length-for-age.
[2] The difference was apparent only during first 6 months of participation; thereafter returned to baseline levels.
[3] Based on comparison of proportions above or below defined cutoffs or differences in mean z-scores.
[4] Based on Quetelet's Index (weight (kg) x (100/height(cm)^2).
[5] WIC participants had slightly lower mean hemoglobin percentile, but the difference was not statistically significant.
[6] The between-group difference was significant when using the criteria defined by Yip et al. (1987) to measure anemia. The difference fell just short of significance when anemia was defined solely on the basis of hematocrit or hemoglobin.
[7] A significant, positive impact reported for the trends analysis that was not limited to WIC children and did not control for SES as well as the WIC-specific multivariate analysis.
[8] Authors reported significant findings at p <0.10.

the rate of weight gain among infants and toddlers, but had to abandon the analysis of impacts on linear growth because of problems with missing data.

The strongest and most recent data on WIC's impacts on the growth of infants and children come from studies by Black et al. (2003) and Lee et al. (2000). Black et al. reported data from the Children's Sentinel Nutrition Assessment Project (C-SNAP). C-SNAP included low-income infants whose caregivers were recruited at six urban medical centers. WIC participation status was not a criterion for enrollment into the study and was not known at the time of recruitment. The study did not collect information on household income, so the authors used the absence of private health insurance as a proxy to identify a comparison group of income-eligible nonparticipants. The authors did not control for selection bias but collected information on reasons for nonparticipation. They used these data to divide infants who were not participating in WIC into two groups: those who did not participate because their caregivers had problems accessing the program (64 percent of the total) and those who did not participate because their caregivers did not perceive a need for WIC services (36 percent). Reported access problems included being on a waiting last, scheduling difficulties, missed appointments, lack of time to pick up vouchers, relocation, and lack of transportation. There were noteworthy differences in the sociodemographic characteristics of the three groups. Caregivers who reported no need for WIC services were more likely than either caregivers of WIC participants or caregivers who reported WIC access problems to be employed, married, and White and were less likely to be receiving subsidized housing, TANF, or food stamps. Caregivers who did not participate in WIC because of reported access problems had lower rates of employment than WIC participants as well as lower rates of participation in other assistance programs.

The study examined z-scores for weight-for-age, length-for-age, and weight-for-length, using age- and gender-specific norms. Because data were collected in medical settings, information was collected on hydration status, which can dramatically affect an infant's weight. The authors used multivariate models to estimate differences between WIC participants and each of the nonparticipant groups. In addition to sociodemographic characteristics, models included variables to control for maternal depression, birthweight, and breastfeeding status.

For both WIC infants and infants who were not participating in WIC because their caregivers did not perceive a need for WIC services, z-scores for weight-for-age and length-for-age indicated that children were growing normally. In contrast, z-scores for both of these measures were below normal for infants who were not participating in WIC because of access problems, indicating that these infants were both underweight and short, relative to national norms.

Multivariate analyses revealed that WIC infants were significantly longer and significantly less underweight than infants who did not participate in WIC because of access problems. Infants who did not participate in WIC because their caregivers did not perceive a need for WIC services were comparable to WIC infants in weight-for-age, but were significantly longer than WIC infants. There were no differences between WIC participants and either group of nonparticipants in the prevalence of overweight. The unadjusted prevalence for all three groups of infants exceeded the 5 percent that would be expected based on national norms (7-9 percent).

The authors concluded that WIC participation has a positive impact on infant growth. While acknowledging the potential for selection bias, the authors suggest that findings from the comparison of WIC participants with the slightly more advantaged comparison group (infants whose caregivers did not perceive a need for WIC services) strengthen this conclusion. Because of differences in sociodemographic characteristics as well as a difference in household food security (WIC participants were more likely to be food insecure), one might expect this group of nonparticipants to do better than WIC participants. However, both groups had comparable weight-for-age and, although nonparticipants were significantly longer, both groups were growing normally. The authors also point out that infants who did not participate in WIC because of access problems had a higher rate of breastfeeding initiation than WIC participants (62 percent vs. 54 percent). Because healthy breastfed infants generally grow more rapidly than nonbreastfed infants during the first two months of life, the unadjusted z-scores observed between these two groups are contrary to what one would expect to see (WIC infants were growing normally, but infants in the WIC-access-problem group had weight-for-age and length-for-age z-scores that were below national norms).

Lee and his colleagues (2000) assessed the impact of WIC participation on the prevalence of failure to thrive. Failure to thrive is a general diagnosis that can have many causes. The sentinal finding, however, is a failure to gain weight and to grow as expected. The authors used a longitudinal, linked database that included, for all children born in Illinois between 1990 and 1996, birth record, WIC, and Medicaid data for 1990 though 1998.[71] The analysis was limited to children who were born between 1990 and 1994 and were continuously enrolled in Medicaid from birth until their fourth birthday. To control for the fact that children diagnosed with failure to thrive may be more likely to participate in WIC—because it is an accepted nutritional risk—the authors included in the WIC participant group only those children whose WIC enrollment predated their diagnosis. Children whose enrollment in WIC occurred after their diagnosis were considered nonparticipants. Results showed that Medicaid children who had ever participated in WIC were significantly less likely than those who never participated to be diagnosed with failure to thrive (based on primary diagnosis in Medicaid claims data).

In recent years, increasing attention has been paid to problems at the opposite end of the growth spectrum—the problem of overweight among children, including very young children. A 1995 CDC report provides suggestive evidence that WIC participation is not associated with the prevalence of overweight among children. Using NHANES-III data, CDC analysts examined children's weight-for-height, relative to national standards, by age and race/ethnicity. They found that differences between WIC and income-eligible nonparticipant children were neither consistent nor statistically significant (CDC, 1995). White and Black WIC children tended to weigh more than low-income nonparticipants of the same race, and Mexican-American WIC children tended to weigh less than their non-WIC counterparts, but none of the differences were statistically significant. Multivariate analysis (not further described) did not change the pattern or significance of the findings.

Data from Black et al. (2004) and Lee et al. (2000) provide suggestive evidence that WIC may have a positive effect on growth in infants and children, and the 1995 CDC study suggests that WIC participation is not associated with excess weight in children. It is doubtful, however, that studies like these can provide definitive answers to questions about WIC's impact on the growth of infants and children. The researchers involved in designing and implementing the field test of USDA's planned WIC Child Impact Study concluded that the only way WIC's impacts on child growth and development—indeed, WIC's impact on virtually any outcome beyond dietary intake—can be reliably assessed is through a longitudinal study that includes serial measurements, repeated at regular intervals, for both WIC participants and nonparticipants (Puma et al., 1991).

Anemia/Iron Status

A number of different methods were used in the 16 studies that examined the impact of WIC on children's iron status, including typical participant vs. nonparticipant designs that made cross-sectional comparisons of single point in time measurements, longitudinal or followup studies in which initial measures for the same individuals were compared at a later time point (designs referred to as "participants, before vs. after" and "participant vs. nonparticipant, before and after" in chapter 2), and time series analyses that used aggregate data to compare the prevalence of anemia in a particular population over time. Although each of these designs has weaknesses, as described in chapter 2, the consistency of findings is compelling. The majority of studies that examined the relationship between WIC participation and iron status/anemia found that WIC participation was associated with an increase in mean levels of hemoglobin or hematocrit and/or a decrease in the prevalence of anemia (table 25). In most cases, these differences were statistically significant.

The most convincing evidence comes from analyses done by Yip and his colleagues at the CDC using PedNSS data (Yip et al., 1987). The CDC researchers looked at the prevalence of anemia in infants and children ages 6-60 months between 1975 to 1985, a period of substantial growth in the WIC program. They documented a steady decline in the prevalence of anemia, from 7.8 percent in 1975 to 2.9 percent in 1985. Using detailed data from one State, the authors demonstrated that the socioeconomic status of the population had remained stable over this period. The authors also compared initial and followup measures of hemoglobin or hematocrit (taken roughly 6 months apart) for approximately 73,000 WIC children. The analysis revealed decreased levels of anemia at followup.

Another CDC analysis reported on trends between 1980 and 1991 (Yip et al., 1992). During this period, the prevalence of anemia decreased by more than 5

[71] The database also included information on FSP and TANF/AFDC participation, which the authors used to examine patterns of program participation during welfare reform in Illinois (1990-98).

percent for most age and race/ethnicity specific subgroups. Other measures of childhood health monitored in PedNSS, including the prevalence of low birthweight, low height-for-age, low weight-for-height, and high weight-for-height (overweight), generally remained stable. Comparable findings have been reported by Sherry et al. (1997; 2001).

The CDC analyses suggest that WIC has a direct impact on the prevalence of childhood anemia as well a probable indirect effect. WIC requires use of iron-fortified infant formulas and includes iron-fortified breakfast cereals in its food packages. Because more than half of all formula sold in the United States, as well as a large proportion of breakfast cereals, are purchased with WIC vouchers (Batten et al., 1990), manufacturers have consciously focused on bringing to market iron-fortified products that are allowable in WIC food packages. These foods have assumed a leading position in their respective markets and have therefore been increasingly consumed by both WIC and non-WIC children. As a result, the WIC program may have contributed to the observed improvement in the prevalence of anemia in the general population of low-income U.S. children.

The declining prevalence of iron deficiency may have diminished the predictive value of anemia as a screen for iron deficiency. When the prevalence of iron deficiency is high, anemia is a good predictor of iron deficiency. However, when the prevalence is low, the majority of anemia (low hemoglobin or hematocrit levels) is due to other causes (U.S. Department of Health and Human Services (HHS), 2000; Sherry et al., 2001). In young children, a likely cause is infection and inflammation associated with viral illness and, to a lesser extent, hereditary anemias (HHS, 2000; Bogen, 2002). This may be the reason that Kahn et al. (2002), in tracking the prevalence of anemia among infants and children in three Illinois clinics between 1997 and 1999, found a substantial amount of crossover between anemic and nonanemic groups over time (Bogen, 2002). Future efforts to examine WIC's impact on the iron status of infants and children should assess the prevalence of iron deficiency and/or iron-deficiency anemia rather than simple anemia. A recent descriptive analysis of NHANES-III data found that WIC children were significantly less likely than income-eligible nonparticipant children to be iron deficient (Cole and Fox, 2004).

General Health Status

A total of four studies examined the health status of WIC and non-WIC infants and/or children using caregiver reports and/or physician reports (table 24). The strongest data are provided by recent studies by Black et al. (2004) and Carlson and Senauer (2003). Both studies suggest a positive WIC impact, as shown in table 25, but the potential for selection bias remains a concern.

Black and her colleagues (2004) assessed differences in the perceptions of caregivers about the health status of urban low-income infants enrolled in the previously described C-SNAP study. Caregivers were asked to rate their infants' health status as excellent, very good, good, fair, or poor. The question and response options were taken directly from the NHANES-III caregivers interview. Results showed that, relative to WIC infants, infants who were not enrolled in WIC because of access problems were significantly more likely to be rated as having fair or poor health. There was no significant difference in the caregiver-rated health status of WIC infants and infants who were not enrolled in WIC because their caregivers did not perceive a need for WIC services.

Carlson and Senauer (2003) assessed WIC impacts on physician-assessed health status using NHANES-III data. Physicians rated children's health status (excellent, very good, good, fair, or poor) after completing a physical examination. Because so few children were reported to be in poor health, the poor and fair categories were combined for the analysis. The authors used ordered probit models to estimate the likelihood of a child being in excellent health. Two analysis samples were used. The "WIC sample" included children between the ages of 24 and 60 months who either participated in WIC or were income-eligible based on household income or Medicaid participation. WIC participation was defined at the household rather than individual level. The "full sample" included all children between the ages of 24 and 60 months who had complete data. Results for both the full sample and the WIC sample indicated that WIC participation had a significant, positive effect on the likelihood that a child would be in excellent health. The size of the effect (increased probability of being in excellent health) ranged from 4.6 to 11.4 percentage points, depending on the model used. Effects were consistently higher in the "WIC sample," indicating that the impact of WIC on health status was most pronounced for poorer children.

The previously described study by Lee et al. (2000) looked at the prevalence of "nutritional deficiencies" among Medicaid children in Illinois who did and did not participate in WIC. The measure, based on primary diagnosis in Medicaid claims data, is not well described, but is said to "include conditions such as malnutrition and vitamin deficiencies." The authors found that children who had ever participated in WIC were significantly less likely than children who had never participated in WIC to be diagnosed with these conditions (finding is not included in table 25). As previously mentioned, the analysis explicitly excluded from the WIC participant group children whose diagnosis predated their WIC enrollment.

Immunization Status

The literature search identified six studies that examined the immunization status of WIC participants relative to nonparticipants (table 24). Results are summarized in table 25. Although this research suggests that WIC has a positive impact on children's receipt of complete and timely immunizations, the findings are particularly vulnerable to selection bias. Mothers who are motivated to enroll their child in WIC may also be motivated to ensure that the child is properly immunized.

The NWE (Rush et al.,1988c) found that children who were enrolled in WIC after the first year of life were significantly more likely than children in the control group to have an immunization card and to have received a measles vaccination (given after 15 months of age). In addition, children whose mothers participated in WIC prenatally and were enrolled in WIC during early infancy were more likely to have received diphtheria-pertussis-tetanus (DPT) immunization and, to a lesser extent, polio vaccines.

James (1998) studied the immunization status of 150 children receiving care at one health care center in New York State. She randomly selected a sample of WIC children who were up to date on immunizations at 12 months of age and matched them on age and gender (only) with subjects from a randomly selected group of non-WIC children who were receiving care at the same health care center. She then documented immunization status at 24 months of age and used chi-square tests to assess differences between the two groups. No significant differences were found. This result is not surprising in view of the fact that all of the study children were clearly in "immunization aware" households (all children had up-to-date immunizations at 1 year of age) and all had a primary source of health care.

Shaheen and her associates (2000) studied immunization coverage among low-income children in Los Angeles. They completed a household enumeration of children ages 24-47 months in 30 randomly selected clusters (block groups) in and around downtown. A random sample of 300 children was selected and their parents or guardians were interviewed in person. Information on immunization status was abstracted from home immunization cards, if available (81 percent of all cases), or obtained from health care providers. WIC participation was positively but not significantly associated with completing immunization series on time. Among children who had not received their first round of immunizations at the recommended age, the combination of WIC participation and having a home immunization card was significantly and positively associated with being fully immunized by 24 months of age. Sample sizes for the latter analysis were very small and may have obscured any independent WIC effect.

Shefer and her colleagues (2001) analyzed data from the 1999 National Immunization Survey (NIS). The NIS has been conducted by the CDC since 1994 to estimate vaccination coverage rates for U.S. children ages 19-35 months. Children were divided into four groups based on WIC participation status and income: currently on WIC, previously on WIC, never on WIC but income-eligible, and never on WIC and not income-eligible. Bivariate comparisons showed that, among children with household incomes at or below 100 percent of poverty, children who had ever participated in WIC were significantly more likely to have up-to-date immunizations at 24 months than children who had never participated in the program (71 percent vs. 56 percent). Moreover, across all income groups, children who currently participated in WIC were more likely than previous WIC participants to have up-to-date immunizations at 24 months (75 percent vs. 69 percent). However, current WIC participants were less well immunized than higher income children who had never been on WIC (75 percent vs. 83 percent).

Luman and her colleagues (2003) expanded on Shefer's work, analyzing data from the 2000 NIS to identify maternal characteristics associated with children's immunization.[72] Children not currently participating in WIC were divided into three nonparticipant categories comparable to those defined by Shefer et al. (2001). A

[72]Luman et al. (2003) characterized WIC participation as a "maternal characteristic," but the 2000 NIS instrument actually collected information on the child's participation (Abt Associates Inc., 2002).

multivariate regression that controlled for child's age showed that children who were currently participating in WIC were significantly more likely than any of the nonparticipant groups to be fully immunized. Children who had never participated in WIC but were income-eligible were least likely to be fully immunized.

The positive WIC impact suggested by this research, if real, may be influenced by an ongoing collaboration between USDA and the CDC to use the WIC program as a means to improve immunization rates among the Nation's low-income children. Since the early 1990s, a variety of strategies has been used to promote timely and complete immunizations among WIC participants, including the following (Shefer et al., 2001):

- Assessment and referral—May occur at each WIC visit or at each 6-month recertification visit and may include a computerized tracking system.
- Escort programs—Children who need immunizations are escorted to locations where immunizations are given.
- Voucher incentive programs—Restrict access to WIC vouchers until a child is fully immunized (for example, require that caregivers come into the WIC clinic every month rather than every 2 months to pick up WIC vouchers).
- Outreach and tracking programs—May involve mail, telephone, or home visit reminders for underimmunized children.

Randomized trials have demonstrated that some of these strategies can dramatically increase immunization coverage among WIC participants (Birkhead et al., 1995; Hutchins et al., 1999). In addition, Shefer et al. (2001) modeled the relationship between WIC immunization activities and immunization rates among WIC children. Using data from the 1999 NIS and data from an annual survey of WIC directors and State immunization program directors, Shefer and her colleagues found that WIC participants in States with high-intensity immunization activities (50 percent or more of WIC children enrolled in sites that implemented an immunization intervention at every visit) had significantly higher rates of up-to-date immunization at 24 months than WIC participants in States with low-intensity immunization activities (less than 50 percent of WIC children enrolled in sites that used an immunization intervention and the intervention was implemented only at recertification visits). Finally, Dietz et al. (2000) found that a WIC voucher incentive program was one of eight factors that had a positive, significant effect on immunization rates in Georgia's public health clinics.

Use and Costs of Health Care Services

The NWE examined use of preventive health care services among WIC and non-WIC infants and children and found no significant difference between the two groups (Rush et al., 1988c). More recently, three studies examined the relationship between children's WIC participation and the use of health care services (Lee et al, 2000; Buescher et al., 2003) and dental care services (Lee et al., 2004a) using datasets similar to the WIC-Medicaid databases used to assess WIC's impact on birthweight (table 24). All three studies reported that WIC participation had a significant, positive effect on the use of health care/dental care services (table 25). These results suggest a positive WIC impact; however, only the study that looked at dental care services controlled for selection bias. Thus, the two studies that assessed use of health care services are vulnerable to potential selection bias—it is possible that children who have health problems or who use more health care services may be more likely to be referred to WIC. In addition, results of all three studies have limited generalizability because they used datasets for a single State (one study used data from Illinois and two used data from North Carolina) and were limited to WIC participants enrolled in Medicaid.

As described previously, Lee et al. (2000) used a longitudinal database that included birth record, WIC, and Medicaid data for all children born in Illinois between 1990 and 1996. They used a proportional hazards model to estimate the effect of WIC participation on the timing of children's first screening in the Early Periodic Screening, Diagnosis, and Treatment (EPSDT) program.[73] Their analysis included all children new to the Medicaid program between 1991 and 1997. The dependent variable was the time between entry into the Medicaid program and receipt of the first EPSDT screening. WIC participation was coded as a time-varying covariate. Results showed that WIC participation had a significant, positive effect on the likelihood of receiving EPSDT screening.

Buescher et al. (2003) and Lee et al. (2004a) used a database that included linked birth certificate, Medicaid, and WIC records for all children born in North Carolina in 1992. Buescher and his colleagues assessed the

[73]EPSDT is a comprehensive, prevention-oriented child health program that State Medicaid agencies are required to provide for all Medicaid recipients under the age of 21. See www.cms.hhs.gov/medicaid/epsdt.

impact of WIC participation on the use and cost of health care services. Lee and her associates focused on WIC impacts on the use of dental care services. They also completed a separate analysis that assessed impacts on dental care costs (Lee et al., 2004b).

Buescher et al. (2003) studied children ages 1-4 who had been continuously enrolled in Medicaid for at least 1 year of life. Separate analyses were completed for four different age cohorts based on completed year of age. A cumulative measure of WIC participation was defined based on the percentage of months from age 1 through the current age in which WIC food vouchers had been redeemed. Three levels of WIC participation were identified: high = more than 66 percent; medium = 34-66 percent; low = 33 percent or less. Because the analysis looked at cumulative use of health care services and cumulative Medicaid costs, this definition of WIC participation was deemed more appropriate than a definition based on current participation.

Tobit regression was used to analyze Medicaid cost data because of the large number of zero values. Logistic regression was used to estimate the odds of having a well-child visit, being hospitalized, having an emergency room visit, and being diagnosed/treated for a common childhood illness. An array of variables was used to control for sociodemographic characteristics of the child and his/her mother, including prenatal WIC participation for the mother and participation in WIC as an infant for the child. In addition, the authors included a variable to designate whether EPSDT services were received in a public health department. This variable helped control for differences in costs associated with public vs. private health care providers, as well as for co-location of WIC clinics with child health care services. The authors attempted to control for selection bias but, after examining several multi-stage models, were unable to identify good predictors of WIC participation that were not also associated with the outcome measures.

Results showed that WIC participation had a significant, positive effect on the likelihood that children would receive any well-child care and on the likelihood that children would receive at least one EPSDT visit per year, as recommended. This effect was noted for all four age cohorts and, with one exception, for all three levels of WIC participation. Comparable results were noted for the likelihood of visiting an emergency room or of being diagnosed with otitis media or upper respiratory infection. Medium to high levels of WIC participation were positively associated with the likelihood of being diagnosed with a lower respiratory infection. Results for other common childhood illnesses (asthma, gastroenteritis, and allergy) varied by age cohort and/or level of WIC participation. In most cases, however, high WIC participation was associated with a significantly greater likelihood of diagnosis for these conditions. A high level of WIC participation was also associated with a significantly greater likelihood of being hospitalized.

Given these patterns, it is not surprising that WIC participation was associated with increased Medicaid expenditures. WIC participation was consistently associated with greater expenditures for outpatient services (all four age cohorts and all three levels of WIC participation). In addition, medium and high levels of WIC participation were generally associated with significantly greater Medicaid costs overall and for individual types of medical care (EPSDT, well-child care, physician services, drugs, and dental care). The authors concluded that “the bottom line is that children enrolled in Medicaid who participate in WIC are linked to the health care system and are much more likely to receive both preventive and curative care, whereas Medicaid-enrolled children who do not participate in WIC simply are not as connected to the health care system.”

Lee et al. (2004a; 2004b) studied the impact of children’s WIC participation on the use and cost of dental care services. Their analysis of dental care use controlled for selection bias by using a two-stage model that incorporated State-level WIC data to predict WIC participation (Lee et al., 2004a). The model included three variables that the authors found to be correlated with WIC participation but not with the use of dental care services, including the number of WIC clinics per county, the number of full-time WIC workers per county, and WIC hours of operation.

The analysis looked at the annual use of dental care services as well as the types of services used (diagnostic/preventive, restorative, emergency) by children ages 1-4. A categorical rather than continuous outcome measure was used to represent annual use of dental care services (no visits, one visit, two or more visits) because the recommended number of visits is two per year and because visits in excess of two per year may be more indicative of severe dental disease than of access to dental care services. WIC participation was measured based on the number of months when any WIC food vouchers were redeemed during each year of life. In addition to controls for sociodemographic characteristics, the model controlled for length of Medicaid enrollment as well as the relative availability of dental practitioners (ratio of dentists per population).

WIC participation was associated with a significant increase in the use of dental care services. Children who participated in WIC for either 6 months or a full year were significantly more likely than children who did not participate in WIC to have both one dental visit per year and two or more dental visits per year. Children who participated in WIC were also significantly more likely to have used preventive and restorative dental health services and significantly less likely to have had an emergency dental visit. The latter finding was significant at the $p < 0.10$ level. The authors suggest that WIC participation provides children with a "better connection to the health care system that can lead to care that is more planned and less urgent."

Lee and her colleagues (2004b) also assessed the impact of WIC participation on Medicaid costs for dental care, but used a slightly different approach. They did not control for selection bias because they had to use a two-stage model to first estimate the probability of a child having any dental care expenditures (many children had no dental care expenditures). In addition, they estimated separate models for infants and for cohorts of children ages 1, 2, and 3. They excluded 4-year-olds from the analysis to minimize the potential for simultaneous determination. Finally, they defined WIC participation as a dichotomous variable, reflecting whether any of the child's WIC food vouchers had been redeemed in each particular year of life. Age-specific models controlled for WIC participation at other ages.

Results showed that, among infants and children ages 1 and 2, WIC participation was associated with a significantly greater likelihood that a child would have some Medicaid charges for dental care services. This relationship was not observed among 3-year-olds. In addition, among infants and 1-year-olds, WIC participation was associated with significantly lower dental care costs (19-20 percent less). No significant differences were detected in total dental care costs for children ages 2 and 3. Investigation of the sources of dental care costs showed that WIC participants were significantly less likely than nonparticipants to have received dental care services in a hospital setting (as opposed to a primary care setting). This difference in dental care source accounts for at least some of the lower cost observed for WIC participants despite a higher prevalence of dental care charges overall. The authors concluded that observed difference between WIC participants and nonparticipants may be the result of nonparticipants having more dental problems and/or a greater tendency to use emergency room services rather than standard outpatient/primary care services.

Cognitive Development and Behavior

Five of the identified studies assessed WIC impacts on measures of cognitive development or behavior (table 24). The NWE assessed children's attention and cognition using three standardized tests known to be responsive to changes in early life: the Infant Behavior Inventory (IBI), the Peabody Picture Vocabulary Test (PPVT), and the McCarthy Scales of Infant Development (Rush et al., 1988c). The results indicated that infants and children whose mothers had participated in WIC prenatally had significantly higher receptive vocabulary scores than infants and children whose mothers had not participated in WIC (table 25). In addition, children who enrolled in WIC after the first year of life had significantly better digit memory (counting backward and forward) than children in the control group. Rush and his colleagues appropriately cautioned that small sample sizes and substantial differences in the socioeconomic status of WIC and control group members limit the strength of these associations.

Hicks, Langham, and Takenaka (1982) studied 21 sibling pairs in Louisiana. One of the siblings (the younger) had received WIC benefits both "prenatally" (during the third trimester), through the first year of life, and on into childhood, while the other (older) sibling received WIC benefits only in childhood—that is, after 1 year of age. The children were studied when the younger children were about 6 years old and the older children were about 8. The "early supplementers" had participated in WIC an average of 56.1 months (counting the prenatal period), while WIC participation for the "late supplementers" averaged 30.8 months.

Investigators used a battery of measures to assess behavior and cognitive performance and also obtained school grades for reading, writing, and arithmetic. Strong, positive, and statistically significant differences, favoring the child with greater WIC exposure, were found for most of the cognitive and behavioral measures assessed, including IQ, attention span, visual-motor synthesis, and school grade point average. The authors attributed these differences to a superior nutrition environment for the "early supplementers" during critical periods of brain development in the last trimester of pregnancy and the first 6 months of life. A followup study completed 32 months later reported that the findings for IQ scores and school grades, the only two measures replicated, still held (Hicks and Langham, 1985).

The Hicks studies have been heavily criticized by others who have studied the effects of nutrition supplementation on cognitive development (Pollitt and Lorimor, 1983). One of the greatest concerns is the magnitude of the differences reported—which exceed many obtained from controlled trials of nutrition supplementation in populations with high prevalence of malnutrition and infectious diseases. Other problems include the small sample size and the potential that the “late supplementers” differ in important ways from the “early supplementers.”

A stronger and more recent study by Kowaleski-Jones and Duncan (2000) examined the impact of prenatal WIC participation on temperament and the development of motor and social skills. The authors used data from the NLSY, focusing on children born to NLSY participants between 1990 and 1996 (collection of data on WIC participation began in 1990).

Temperament was measured with a composite “difficult temperament” index, which included subscales for predictability, fearfulness, positive affect, and friendliness—factors thought to be precursors of personality development and social adjustment. Motor and social skills were assessed based on an established mother-reported scale that measures motor, social, and cognitive development of young children from birth though age 3. The analysis used the earliest available measures for each child. Measurements for about half of the children were collected during their first year of life. Measures for the other half were collected between their first and second birthdays. Analytic models controlled for the child’s age at the time of measurement.

The authors used both standard regression models and fixed-effects models, based on sibling pairs, to estimate WIC impacts. Three different specifications were used for both models: one that controlled for the child’s sociodemographic characteristics, one that added an array of prenatal and maternal characteristics (many of which dropped out in the fixed-effects model), and one that also controlled for prenatal participation in the FSP.

For the difficult temperament index, the direction of the coefficient for prenatal WIC participation varied between the standard regression models (positive coefficient, indicating that WIC participation was associated with an increased likelihood of having difficult temperament) and the fixed-effects models (negative coefficient, indicating that WIC participation was associated with a decreased likelihood of having a difficult temperament). The only model in which WIC participation was significant at the $p < 0.05$ level or better was the simplest regression model, which did not control for prenatal and maternal characteristics or for FSP participation. However, the authors reported a significant, positive WIC effect based on results from the fixed-effects model that was significant at the $p < 0.10$ level. The direction of WIC coefficients in the models that estimated impacts on motor and social skills was also sensitive to specification, and none of the models found a significant WIC effect, even at $p < 0.10$.

Food Security

Only one of the identified studies used the 18-item USDA food security module to assess the impact of WIC participation on household food security. In the previously described C-SNAP study, Black et al. (2004) assessed household food security among low-income infants who did and did not participate in WIC. The authors found, relative to WIC participants, a significantly lower rate of household food insecurity (or a higher level of food security) among infants who were not participating in WIC because their caregivers did not perceive a need for WIC services. There was no significant difference in household food insecurity between WIC participants and nonparticipants who did not participate because of access problems.

Impacts of WIC Participation on Nonbreastfeeding Postpartum Woman and Breastfeeding Women

The literature search identified two studies that assessed WIC impacts on nonbreastfeeding postpartum WIC participants and only one study that looked at the impact of WIC participation on breastfeeding participants. In addition, the previously described study by Kramer-LeBlanc et al. (1999) compared dietary intakes of breastfeeding and nonbreastfeeding postpartum WIC participants to income-eligible nonparticipants. The analysis of breastfeeding women was hampered by small sample sizes. The analysis of nonbreastfeeding postpartum women showed that WIC participants consumed significantly more calcium, riboflavin, and retinol than nonparticipants.

Nonbreastfeeding Postpartum Women

Pehrsson et al. (2001) assessed iron status among nonbreastfeeding postpartum women. The study took place during a time when some counties in Maryland were certifying only high-risk nonbreastfeeding postpartum women because of funding shortages. The participant group included 57 low-risk WIC participants who were recruited from WIC sites in Baltimore City, which was enrolling all eligible postpartum applicants. The nonparticipant group included 53 WIC-eligible women who were recruited from WIC sites in counties that were enrolling only high-risk women. Subjects were matched on race and age. All were older than 19, had delivered a full-term infant the preceding month, were free of major health problems, and qualified as low-risk nonbreastfeeding postpartum participants.

Women were recruited into the study within 30 days of delivery and were followed at 2, 4, and 6 months postpartum. Major outcome variables included four measures of iron status (hemoglobin, transferrin receptor, ferritin, and ratio of transferrin receptor to ferritin). Dietary iron intake was estimated using a self-administered food frequency questionnaire designed for respondents with low levels of literacy.

Although mean hemoglobin concentrations were comparable at baseline, the mean for WIC participants increased over time. At 6 months postpartum, the difference was statistically significant, after controlling for FSP participation, smoking status, use of iron supplements, and interpregnancy interval (months elapsed between immediately preceding pregnancy and prior pregnancy). Moreover, at 6 months postpartum, significantly more nonparticipants than participants were anemic based on the CDC-recommended cutoff for hemoglobin. No significant differences between WIC participants and nonparticipants were detected for any of the other measures of iron status or for dietary intake of iron.

The authors concluded that nonbreastfeeding postpartum WIC participants who experienced 6 uninterrupted months of participation were significantly less likely to become anemic than comparable women who did not participate in WIC during the postpartum period. Because they observed no difference between groups in means for the other measures of iron status, in the percentage of women classified as iron deficient based on these measures, or in dietary iron intake, the authors concluded that observed differences in hemoglobin concentrations and in the prevalence of anemia may not be associated with improvements in iron status among participants. Rather, these differences may be attributable to increased rates of other nutritional deficiencies, compromised health care, and infection or inflammation among nonparticipants.

This study may have underestimated WIC's effect on the iron status of postpartum women because most of the women, including all but two of the nonparticipants, participated in WIC during pregnancy and because all subjects were relatively iron replete when they entered the postpartum period. In addition, these authors, like Rush et al. (1988d), discussed the myriad factors that can influence iron status and recommend that future studies collect an expansive set of variables that will allow for a more sophisticated analysis. These include biochemical indicators of infection and inflammation, menstrual history, use of oral contraceptives and reestablishment of menses, and medical documentation on the presence of infection, inflammation, and conditions that can affect blood-related measures (for example, sickle-cell anemia and thalassemia).

In the other identified study of nonbreastfeeding postpartum women, Caan et al. (1987) studied the benefits of WIC participation during the interpregnancy interval, looking at women's nutritional status at the start of the second pregnancy and birth outcomes of that pregnancy. The study involved 47 local WIC agencies in California that had different policies for enrolling nonlactating postpartum women between 1981 and 1983. Because of funding shortages during that period, some local agencies were not able to serve these lower priority participants.

In 1983, researchers recruited newly enrolling pregnant women in both types of local agencies (agencies that had and had not served nonbreastfeeding postpartum women between 1981 and 1983). To be eligible to participate in the study, women had to meet the following criteria: (1) given birth to another infant between 1981 and 1983; (2) participated in WIC during the previous pregnancy; and (3) did not breastfeed the first infant. Women were divided into two groups based on their postpartum participation after the previous pregnancy: an extended feeding group, which included women who had received postpartum WIC benefits for 5-7 months, and a limited feeding group, which included women who received postpartum benefits for 0-2 months. Both groups had a comparable interpregnancy period (the time elapsed between first and second pregnancies) of 3 years or less.

The final analysis sample included 642 women (307 limited feeding and 335 extended feeding). The study found a positive, significant impact of extended WIC participation after the first pregnancy on both birthweight and birth length of the second infant. The odds ratio of having a low-birthweight infant approached significance, but, because low birthweight is a rare event, small sample sizes hampered the analysis (24 infants, 5.1 percent of all infants in the limited feeding group and 3.2 percent of all infants in the extended feeding group).

Positive effects from WIC participation were also reported for maternal outcomes. Women in the extended feeding group who had been obese at the start of the first pregnancy were 50 percent less likely than comparable women in the limited feeding group to be obese at the start of the second pregnancy. Although not a statistically significant trend, women in the extended feeding group who had been underweight at the onset of the first pregnancy tended to weigh more at the onset of the second pregnancy. Finally, mean hemoglobin levels (measured at the time of enrollment for the second pregnancy) were significantly higher in the extended feeding group; however, women were no more likely than those in the limited feeding group to be anemic.

Caan and her colleagues point out that evidence from other studies suggests that physiologic and metabolic adjustments associated with pregnancy proceed more normally in women whose nutritional status is good at the beginning and very early stages of pregnancy. Thus, the authors assert, among women with short interpregnancy intervals, WIC participation during the postpartum period may have an even stronger positive impact on birth outcomes than prenatal participation alone, especially for women who might not enroll in WIC until the second trimester of pregnancy. The authors appropriately acknowledge that their study has several limitations, including exclusion of a subgroup of recruited women because of problems with missing data and the potential bias associated with the fact that women in each study group were drawn from mutually exclusive sets of local agencies.

While further research is needed to replicate or expand the work done by Pehrsson et al. and Caan et al., these studies are important in that they provide the only source of information on potential WIC impacts among nonbreastfeeding postpartum women, the program's lowest priority group. If the hypotheses outlined by these researchers, particularly those of Caan et al., are valid, there may be reason to rethink the low priority assigned to this participant group.

Breastfeeding Women

In addition to the descriptive study by Kramer-LeBlanc et al. (1999), the only study that focused specifically on breastfeeding women examined nutrient intakes in a very small convenience sample of breastfeeding WIC participants (n=11) and an even smaller sample of middle-class breastfeeders not participating in WIC (n=5) (Argeanas and Harrill, 1979). Researchers collected 24-hour dietary recalls from each subject at approximately 6 weeks postpartum and again 2 months later. The authors reported that the middle class non-WIC women had higher mean intakes of energy and nutrients at the time of the first interview. WIC participants significantly increased their intakes over the 2-month study period, while nonparticipants' intakes decreased, resulting in comparable intakes for the two groups. While the results are intriguing, little can be concluded from this dated, poorly designed study.

Impacts of WIC Participation on WIC Households or Undifferentiated WIC Participants

Five of the identified studies looked at the impact of WIC participation on all types of WIC participants (without differentiating women, infants, and/or children) or on household-level outcomes. Two studies looked at dietary quality, one study examined household food use, and two studies estimated impacts on household food expenditures. Both of the latter studies used data from the NWE.

Dietary Quality

Basiotis, LeBlanc, and Kennedy (1998) used data from the 1989-91 CSFII to look at dietary quality among low-income households eligible to participate in the FSP (income less than 130 percent of poverty) and assessed the impact of participation in the FSP (entire household) and WIC (any household member). Dependent measures used in the study were the Healthy Eating Index (HEI) and its component scores.

The authors found that having one or more household members participate in WIC was associated with a very strong positive impact on dietary quality. Specifically, overall HEI scores for households with one or more WIC participants were 23 points higher than scores for other households, a substantial effect given that the mean score for all of the low-income households included in the sample was 62 points. WIC participation was also associated with significant increases in all component scores except those associated with vegetable consumption and intake of saturated fat.

Wilde et al. (2000) used more recent CSFII data (1994-96) to estimate the impact of WIC participation on dietary quality. This study used data on Food Group Pyramid servings to examine impacts on intake of meats, fruits, vegetables, grains, dairy, added sugars, and added fats. The only significant effect noted for WIC was a positive one for intake of added sugars (fewer teaspoons). Results did not differentiate between women participants and child participants. The authors suggest that this effect may result from participants substituting WIC-supplied fruit juices and cereals for higher-sugar soft drinks and cereals.

While these studies are important, in that they are the only ones to examine WIC impacts on dietary quality, expanding the focus to impacts on particular types of WIC participants would be useful. Although the number of pregnant and postpartum women is likely to be small in the CSFII database, the combined CSFII 1994-96, 1998 CSFII database includes a substantial number of age-eligible children and a reasonable number of infants.

Household Food Use

Taren et al. (1990) studied food use among low-income households. The sample included families participating in food cooperatives for low-income families in Hillsborough County, FL, as well as families participating in the local Expanded Food and Nutrition Education Program (EFNEP). Data were collected on the number of servings of 27 different foods used in the household the previous week. A serving was defined as the preparation and offering of a particular food, without attention to portion size or multiple helpings during the same meal.

Multiple regression analysis was used to identify factors associated with the number of family food servings used per week. Participation in WIC had a positive, significant impact on the number of servings of food used per week. The report does not provide details about the food list used in the study or about relative impacts for different categories of food, making it impossible to determine whether the list gave substantially more weight to WIC foods than to other foods or the relative contribution of WIC foods to the overall total.

Household Food Expenditures

The NWE included a substudy to examine the impact of WIC participation on household food expenditures (Rush et al., 1988b).[74] The researchers concluded, however, that the study could provide little useful information because of three key problems: disparities in family income and food expenditures between WIC and non-WIC households that actually became worse after statistical controls for several sociodemographic characteristics; disparate results for data collected using different methods (diary vs. recall); and a devaluing of the WIC food package by WIC participants.[75]

Arcia, Crouch, and Kulka (1990) reanalyzed the NWE data and estimated empirical models of WIC impacts on monthly food expenditures; the degree to which WIC benefits substituted for foods that would have been purchased anyway; and the degree to which WIC benefits were shared with unintended family members. These researchers concluded that participation in the WIC program by a pregnant woman has a more significant impact on the type of foods households purchase than on how much is spent. Participation by a child, on the other hand, was reported to have a positive effect on both food expenditures and food purchases.

It is difficult to draw conclusions about WIC impacts on household food expenditures given the two divergent conclusions drawn from the same data set. However, Rush and his colleagues make a compelling argument that limitations of both the sample drawn for this substudy and the data collected make it difficult to have confidence in the findings from any analysis (Rush et al., 1988b).

Summary

The preceding discussion clearly illustrates that an extensive amount of research has been conducted on the WIC program. At the same time, it demonstrates that coverage of the five different participant groups is very uneven in the existing research and that important gaps remain in information about potential program impacts.

Research is most extensive in the area of birth outcomes. Although concerns about self selection persist, the sheer volume of studies that have reported significant impacts—in different subgroups of WIC participants, at different points in time, and using different research designs and analysis methods—suggests that WIC does have a positive impact on birthweight, as well as a number of other birth-related outcomes, and

[74]Fraker, Long, and Post (1990) attempted to study the impact of WIC and FSP participation on household food expenditures using data from the 1985 CSFII. The authors concluded that they could not reliably estimate the impact of WIC, however, because of small sample sizes, the apparent complexity of the relationship between WIC participation and food expenditures, and a lack of relevant variables for use in modeling. There was evidence that the effect of the WIC program on household expenditures may vary, depending on the number and type of WIC participants in the household.

[75]WIC vouchers and checks specify particular types and amounts of food that can be purchased but do not include information on currency value (like food stamps do). Therefore, food expenditures estimated by simple recall are more prone to underestimation (devaluing) than those estimated by the diary method where every item is reported and valued individually. Moreover, WIC participants may be less aware of the actual cost of WIC food items than their nonparticipant counterparts.

significantly lowers birth-related Medicaid costs. Because of the design characteristics that contribute to inherent underestimation or overestimation of WIC impacts and the wide range of reported estimates, characterizing the relative size of WIC's impact with any confidence is difficult (for example, the estimated reduction in the prevalence of low-birthweight infants). Moreover, subgroup analyses completed by some researchers suggest that WIC impacts are likely to be greatest among Blacks and the lowest income women, groups with the highest incidence of low birthweight.

In addition, many important changes have taken place since most of the available research was conducted. These changes may influence the extent to which findings from previous research apply to the WIC program as it operates today. Some of the most noteworthy changes include: a substantially higher level of program penetration in most areas of the United States than was present in the mid- to late 1980s when most of the research was completed (that is, most eligible prenatal applicants are able to enroll in the program); more generous Medicaid income-eligibility criteria for pregnant women (including some that exceed the WIC cutoff of 185 percent of poverty), which infers automatic income-eligibility for WIC; and the use of standardized nutritional risk criteria. Furthermore, welfare reform legislation, which did not affect WIC directly, may have affected the circumstances of both WIC participants and nonparticipants. Any of these changes may influence both the presence and size of WIC impacts, as well as variations in impacts across subgroups.

In an ideal world, USDA would be able to periodically complete studies like the WIC/Medicaid study *at the national level*. The seeds for such an undertaking have been planted. The 2003 revisions to the U.S. Standard Certificate of Live Birth include the addition of an item to collect information about WIC participation during pregnancy.[76] Some States already collect this information and the hope is that all States will do so by 2009 (Sondik, 2003). Until data are available nationwide, an updated WIC/Medicaid study that uses data from States that do include WIC information on birth certificates is an attractive option.

Research on WIC impacts on pregnant women (other than impacts on birth outcomes) is scarce and relatively dated. Even less is known about impacts on breastfeeding and nonbreastfeeding postpartum women. Exploration of impacts on postpartum participants seems especially important to pursue. The limited available research suggests that postpartum WIC participation may be associated with improved birth outcomes in the subsequent pregnancy and with improved nutrition, health, and/or weight status for the women. If these relationships are confirmed through more definitive research, there may be reason to rethink the lower priority assigned to nonbreastfeeding postpartum women. In view of the ongoing obesity epidemic, the potential for WIC to play a role in addressing pregnancy-related weight retention, which seems to be especially prevalent among minority women (Gore et al., 2003; Abrams et al., 2000), seems particularly important.

There is no solid evidence about the impact of WIC on the initiation and duration of breastfeeding. Moreover, most of the studies that are available were completed prior to a considerable expansion of breastfeeding promotion efforts in the WIC program. Some early studies suggested that WIC participants may follow recommended infant feeding guidelines more closely than nonparticipants, delaying introduction of cow's milk until infants are 1 year and delaying the introduction of solid foods until 4-6 months. However, recent descriptive studies raise doubts about whether these differences persist today. An updated study of WIC's impacts on infant feeding practices would fill these important information gaps. Attention to selection-bias issues will be especially critical for such a study.

Finally, although recent research has begun to fill an information gap that existed for many years, the basis is small for drawing definitive conclusions about WIC's short- and long-term impacts on infants and children, the majority participant groups. The evidence is fairly strong that WIC improves children's iron status. Recent studies suggest that WIC participation positively affects children's use of health care services, immunization status, and overall health, however, potential selection bias remains a concern. Little is known about the impact of WIC on children's long-term health and development. Moreover, while evidence is convincing that WIC participation increases children's intakes of selected nutrients, the influence of these increases on the extent to which WIC children consume adequate diets is not clear. An updated version of the WIC Child Impact Study planned some years ago seems overdue.

[76]The item reads, "Did mother get WIC food for herself during this pregnancy?" Revised birth certificate available at www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf. Accessed June 2004.

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