

# The Impact of Prenatal WIC Participation on Infant Mortality and Racial Disparities

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The infant mortality rate (IMR) is a key indicator of the health status of a community, and reduction of infant mortality is one of the stated goals of the Healthy People 2010 consensus document.<sup>1</sup> Racial disparities in IMR have been documented repeatedly; African Americans and other racial/ethnic minority groups experience an IMR that is significantly higher than the IMR Whites experience.<sup>2</sup> Factors influencing the birth of extremely preterm infants as well as access to specialized obstetric and pediatric care primarily determine disparities in neonatal mortality.<sup>2</sup> Because neonatal mortality accounts for about 67% of the national IMR, risk of preterm birth is an important factor to assess when seeking to decrease infant mortality.<sup>3</sup>

The Hamilton County, Ohio, IMR averaged 11 deaths per 1000 live births during 2003–2007 according to data compiled and provided via e-mail by J. Besl (project analyst, Child Policy Research Center, Cincinnati Children's Hospital Medical Center, April 2009). This IMR is significantly higher than the Ohio state IMR (about 7.8 deaths per 1000 live births for 2003–2007) and nearly twice the IMR for the United States (6.8 deaths per 1000 live births for 2003–2005). In multiyear trending analysis, the Hamilton County IMR has increased slightly since 1990, whereas the IMR for the United States has decreased slightly.<sup>3</sup>

Hamilton County has a marked racial disparity in IMR. The 2003–2005 average IMR for Whites in Hamilton County was 7.0 compared with 19.3 for African Americans. The US average IMR for 2003–2005 was 5.7 for Whites and 13.3 for African Americans.<sup>3</sup>

The percentage of live births delivered preterm nationally increased from 11.0% in 1996 to 12.8% in 2006. This masks a large racial disparity in preterm births in African Americans: 17.9% of live births in African Americans and 11.8% of live births in Whites were preterm in 2004–2006. Hamilton County had a similar increase in preterm live births: from 11.0% in 1996 to 13.3% in 2006. Racial

**Objectives.** We assessed the value of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) services as a public health intervention seeking to improve birth outcomes and reduce racial disparities.

**Methods.** We compared the infant mortality rate (IMR) per 1000 live births and percentage of preterm births overall and by race for prenatal WIC versus non-WIC participants in Hamilton County, Ohio, from 2005 to 2008.

**Results.** The IMR was lower for WIC participants than for non-WIC participants (8.0 vs 10.6;  $P=.04$ ). For African Americans, the IMR of WIC participants was much lower than that of non-WIC participants (9.6 vs 21.0;  $P<.001$ ). For Whites, IMR and preterm birth rates were not improved by WIC participation; however, there was a higher rate of maternal smoking among Whites. The racial disparity in IMR was dramatically reduced in WIC participants (9.6 for African Americans vs 6.7 for Whites;  $P=.14$ ) as compared with non-WIC participants (21.0 for African Americans vs 7.8 for Whites;  $P<.001$ ).

**Conclusions.** Prenatal WIC participation is associated with significant improvements in African American IMR. WIC participation reduces racial disparities in IMR between African Americans and Whites. (*Am J Public Health*. Published online ahead of print February 10, 2010: e1–e6. doi:10.2105/AJPH.2009.168922)

disparities in preterm births in Hamilton County mirror the national landscape, with 17.9% of African Americans births compared with 12.0% of White births classified as preterm.<sup>3</sup>

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) began as a pilot program in 1972 to improve the nutritional status and health outcomes of vulnerable populations. Permanently authorized in 1974, WIC provides supplemental food, nutrition counseling, and health services referrals for low-income pregnant women, breastfeeding mothers, nonbreastfeeding postpartum mothers, and infants and children who are found to be at nutritional risk. Nationally, more than 8.7 million women and children participated in WIC in 2008. The Hamilton County WIC program, administered by the Cincinnati Health Department since 1974, served approximately 22 000 women and children through 17 different locations in 2008.<sup>4</sup>

Researchers in previous studies of women enrolled in WIC have assessed adverse birth

outcomes such as low birthweight and prematurity. The majority of studies on the effectiveness of WIC in improving outcomes were completed more than 20 years ago. The National WIC Evaluation, conducted during the early 1980s and considered the most comprehensive WIC program evaluation, found a clear reduction in neonatal mortality rates and reduced preterm delivery among women enrolled in WIC prenatally.<sup>5</sup>

A major criticism of studies of WIC outcomes is that they have not properly controlled for selection bias into WIC, which may inadvertently improve reported outcomes for WIC participants.<sup>6</sup> In a study of data from the national Pregnancy Risk Assessment Monitoring System, researchers found strong evidence of a negative selection bias, suggesting WIC mothers have poorer forecasted birth outcomes than their non-WIC counterparts.<sup>7</sup> In a longitudinal survey, Kowaleski-Jones and Duncan used a sibling fixed-effects model to account for selection bias and found an increase in birthweight for infants born to mothers who were prenatally enrolled in WIC.<sup>8</sup> Although

researchers have continued to assess preterm delivery, birthweight, and fetal death,<sup>7,9,10</sup> the effect of WIC participation on infant mortality has been little studied since the 1980 National WIC Evaluation. Racial disparities in infant mortality and the effect of WIC on reducing these disparities has not been assessed recently.

There is little evidence in the clinical literature to associate prenatal supplements of healthy food with a reduction in preterm delivery.<sup>11</sup> However, as argued by El-Bastawissi et al., WIC provides a number of services that may affect birth outcomes, including nutrition assessments, counseling and education, breastfeeding promotion and support, immunization screening, connections to Medicaid, and referrals to prenatal care and social services.<sup>9</sup>

We sought to reassess whether prenatal participation in WIC services reduced rates of prematurity and infant mortality overall, as well as among African American participants. Previous studies, as well as an assessment of services provided by WIC, suggest that WIC participants will have improved birth outcomes compared with their non-WIC counterparts and that WIC may reduce racial disparities among participants.

## METHODS

We used a retrospective cohort design. We obtained data files containing WIC prenatal participant data for women residing in Hamilton County in 2005 to 2007 from the Ohio Department of Health, Bureau of Nutrition Services. The data elements included the mother's name, birth date, address, and zip code and the enrollment date in WIC prenatal services. We counted mothers who had more than 1 pregnancy in the study period separately for each birth. After excluding duplicate records, we identified 18 091 women enrolled in WIC in the prenatal period and linked these women to infant outcomes using infant birth and infant death records (Table 1).

We obtained information on all births that occurred in hospitals within the city of Cincinnati from the Ohio Department of Health, Department of Vital Statistics for 2005–2007. Birth record information included demographic, behavioral, and obstetric risk factors that have been shown to negatively affect pregnancy outcomes (Tables 2 and 3).<sup>9</sup> Birth data included

**TABLE 1—Participant Selection and Final Sample Size for Infant Mortality and Preterm Birth Analyses: Hamilton County, OH, 2005–2007**

	Prenatal WIC, No.	Comparison Group, No.	Total, No.
Starting number	18 091	23 205	41 296
Exclusions			
Reported as prenatal WIC but unable to locate infant birth record	7 174	NA	7 174
Not a resident of Hamilton County per birth record	218	7 678	7 896
Multiple gestation (twins, triplets, etc.)	532	942	1 474
Records included in infant mortality rate analysis	10 167	14 585	24 752
Additional exclusions for preterm birth analysis			
Gestational age <20 wk	4	22	26
Gestational age >42 wk	6	14	20
Missing gestational age	410	288	698
Records included in preterm birth analyses	9 747	14 261	24 008

Note. WIC=Special Supplemental Nutrition Program for Women, Infants, and Children; NA=not available.

gestational age, race/ethnicity, the mother's behavioral risk factors, and the mother's pregnancy history. We removed any duplicate infant birth records from the data set before analysis. We excluded mothers who had a multiple gestation from the analysis (i.e., we included only singleton births).

We then linked the WIC prenatal enrollee data to the live birth data using a Visual Basic (Microsoft Corporation, Redmond, WA) program that matched records by assigning points to the following data elements: the mother's birth date (3 points), mother's last name (5), mother's first name (2), mother's first initial (1), mother's middle initial (1), street name (1), and 5-digit zip code (1). If a potential match between a mother and a birth scored 11 points or more, the match was automatically accepted. We manually reviewed all remaining potential matches with 6 to 10 points. To check for keying or spelling variations, we used Visual Basic queries with a soundex version (phonetic match) of first and last names.

We sorted women with more than 1 pregnancy between 2005 and 2007 by date of enrollment in WIC prenatal services and chronologically matched births to the sequential enrollment dates. We excluded births (7 896 births) to women residing outside Hamilton County, as indicated by the birth record. We were able to match 10 167 (59%) of the eligible women participating in WIC

prenatally to birth records for an infant. We used the 14 585 births that occurred in women who did not participate in WIC prenatally as a comparison group (Table 1).

We received data on infant deaths in Hamilton County in yearly data files for 2005–2008 from the Ohio Department of Health, Department of Vital Statistics. We extended the period for receiving death data to 2008 to allow a full year of follow-up for mortality in infants born in 2007. We abstracted death data from the infant death certificate. To link infant death records, we used a Visual Basic program to assign points to data elements as follows: child's birth date (3 points), child's last name (5), child's first name (2), child's first initial (1), child's middle initial (1), and 5-digit zip code (1). We matched the deaths to both the prenatal WIC participants file and the comparison group file. If a death record scored 11 or more points, the record was automatically matched. We then manually reviewed and matched all remaining records with 6 to 10 points as appropriate. We used soundex queries like those described for the birth records to identify potential phonetic matches for manual review. We matched 94 infant deaths to the prenatal WIC group and 190 deaths to the non-WIC comparison group. We excluded an additional 302 deaths that we could not match to either group from the analysis (this included infants of multiple gestations).

**TABLE 2—Demographic Characteristics of Hamilton County, OH, Pregnant Women Who Delivered in Cincinnati Hospitals, by Prenatal WIC Participation: 2005–2007**

Characteristic	Prenatal WIC, No. (%)	Non-WIC Comparison Group, No. (%)	<i>P</i> <sup>a</sup>
<b>Race/ethnicity</b>			
White (Ref)	3456 (34.0)	10074 (69.1)	
African American	5731 (56.4)	3335 (22.9)	<.001
Other/unknown <sup>b</sup>	980 (9.6)	1176 (8.1)	
<b>Maternal age at delivery, y</b>			
<20 (Ref)	1986 (19.5)	773 (5.3)	
20–34	7656 (75.3)	10954 (75.1)	<.001
≥35	525 (5.2)	2854 (19.6)	<.001
Unknown <sup>c</sup>	0 (0.0)	4 (0.0)	
<b>Education, y</b>			
1–11 (Ref)	3490 (34.3)	1880 (12.9)	
12	3334 (32.8)	2534 (17.4)	<.001
≥13	2581 (25.4)	9538 (65.4)	<.001
Unknown <sup>c</sup>	762 (7.5)	633 (4.3)	
<b>Previous births</b>			
None (Ref)	3983 (39.2)	5511 (37.8)	
≥1	5467 (53.8)	8673 (59.5)	<.001
Unknown <sup>c</sup>	717 (7.1)	401 (2.7)	
<b>Household income proxy<sup>d</sup></b>			
<10 (Ref)	5522 (54.5)	11449 (78.9)	
10–30	3027 (29.9)	2340 (16.1)	<.001
>30	1578 (15.6)	720 (5.0)	<.001

Note. WIC=Special Supplemental Nutrition Program for Women, Infants, and Children; FPL=federal poverty line. For the prenatal WIC group, n=10167; for the non-WIC group, n=14585.

<sup>a</sup>*P* value compares each level of a variable with the reference group for that variable.

<sup>b</sup>“Other/unknown” combines all remaining racial/ethnic populations and those of “unknown” race, as these groups do not have a large enough sample size in the data set to be analyzed separately; as such, the *P* value has not been calculated for this group.

<sup>c</sup>Unknown represents the number of participants for which the identified data was not available. These participants were therefore not included in a *P* value calculation.

<sup>d</sup>The percentage of families with income below the federal poverty level in the participant’s zip code of residence. A total of 40 WIC participants and 76 non-WIC participants were not included in the zip code analysis because of incomplete address information.

### Definition of Variables

We abstracted all pregnancy and birth outcomes included in our analysis from the infant birth or death certificates. Preterm birth was defined as a birth that occurred between 20 and less than 37 completed weeks of gestation.<sup>9–12</sup> We further categorized preterm births as moderately preterm delivery (birth at 34–36 weeks gestation) and extremely preterm (birth between 20 and <34 weeks gestation).<sup>9–12</sup> Infant death was defined as the death of a live-born infant during the first year of life.<sup>13,14</sup> IMR was defined as the number of deaths to infants younger than 1 year per 1000 live births for the population selected.<sup>14</sup> The neonatal mortality

rate was defined as the number of deaths to live-born infants through 28 days of life per 1000 live births for the population selected.<sup>1</sup>

We characterized income by the percentage of families with income below the federal poverty line (for the years 2005 to 2008, as defined by the US Census) living in the same zip code as the study participant (Table 2).

### Data Analysis

We used the  $\chi^2$  test to compare demographic characteristics, risk factors, and birth outcomes between the mothers participating in WIC prenatally and the comparison group of mothers not prenatally enrolled in WIC (Tables

2 and 3). We computed birth outcomes for prenatal WIC enrollees versus the non-WIC comparison group within the African American and White subgroups on the basis of race as declared in the birth record (Table 4). We assessed African American and White racial groups as defined by the Ohio Department of Health and combined the remaining racial categories into an “other/unknown” category because of small sample size.

### RESULTS

Prenatal WIC participants were more likely to be African American ( $P<.001$ ), to be of younger age ( $P<.001$ ), to have a high school level education or less ( $P<.001$ ), and to report smoking during their pregnancy ( $P<.001$ ), and they were less likely to have had a previous birth ( $P<.001$ ; Tables 2 and 3) than was the non-WIC comparison group. Prenatal WIC participants were also more likely to live in zip codes with higher rates of poverty than were women in the comparison group ( $P<.001$ ); residence in a high poverty neighborhood is ordinarily expected to be associated with worse pregnancy outcomes (Table 2). There was no difference between the groups regarding chronic diabetes or hypertension ( $P>.05$ ), but prenatal WIC participants were slightly less likely to experience pregnancy-induced hypertension ( $P=.022$ ; Table 3).

White women who were enrolled in WIC prenatally were more than 5 times as likely to have smoked during their pregnancy than were White women in the non-WIC comparison group (64.9% vs 12.2%;  $P<.001$ ). The percentage of African American women who smoked did not significantly vary between the WIC and non-WIC comparison group (13.5% vs 14.7%;  $P=.19$ ).

Overall, women who enrolled prenatally in WIC were slightly less likely to experience an infant death ( $P=.039$ ; Table 3). However, there was a marked difference in outcomes depending on racial group. African American women enrolled in WIC prenatally were much less likely to experience an infant death than were women in the non-WIC African American comparison group ( $P<.001$ ). The IMR among White women was not significantly different between prenatal WIC participants and non-WIC participants ( $P=.49$ ; Table 4).

**TABLE 3—Behavioral and Obstetrical Risk Factors and Birth Outcomes for Women in the Prenatal WIC Group and the Non-WIC Comparison Group: Hamilton County, OH, 2005–2007**

	Prenatal WIC, No. (%)	Comparison Group, No. (%)	P
<b>Current pregnancy characteristics<sup>a</sup></b>			
Smoked during pregnancy			<.001
No	7526 (74.0)	12 643 (86.7)	
Yes	2126 (20.9)	1572 (10.8)	
Unknown	515 (5.1)	370 (2.5)	
Drank during pregnancy			<.001
No	9557 (94.0)	14 079 (96.5)	
Yes	30 (0.3)	104 (0.7)	
Unknown	580 (5.7)	402 (2.8)	
<b>Obstetric risk factors<sup>a</sup></b>			
Chronic diabetes			.18
No	9979 (98.2)	14 280 (97.9)	
Yes	188 (1.8)	305 (2.1)	
Chronic hypertension			.12
No	9944 (97.8)	14 220 (97.5)	
Yes	223 (2.2)	365 (2.5)	
Pregnancy-induced hypertension			.022
No	10 000 (98.4)	14 287 (98.0)	
Yes	167 (1.6)	298 (2.0)	
<b>Pregnancy outcomes</b>			
Gestational age <sup>b</sup>			
Term (Ref)	8549 (87.7)	12 614 (88.5)	
Preterm	1198 (12.3)	1647 (11.5)	.081 <sup>c</sup>
Moderately preterm	877 (9.0)	1077 (7.6)	<.001 <sup>d</sup>
Extreme preterm	321 (3.3)	570 (4.0)	.009 <sup>e</sup>
Infant mortality rate per 1000 <sup>a,f</sup>	81 (8.0)	154 (10.6)	.039

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

<sup>a</sup>The total sample size for the WIC population was n = 10 167; for the non-WIC comparison group, n = 14 585.

<sup>b</sup>The sample size for the WIC population was n = 9747; for the non-WIC comparison group, n = 14 261. Gestational age categories were: term, ≥37 weeks; preterm, <37 weeks; moderately preterm, 34–36 weeks; and extreme preterm <34 weeks.

<sup>c</sup>For preterm vs term.

<sup>d</sup>For moderate preterm vs term.

<sup>e</sup>For extreme preterm vs term.

<sup>f</sup>Infant mortality was defined as death from birth to within 365 days of birth.

The wide racial disparity in IMR was dramatically reduced for prenatal WIC participants (9.6 for African Americans vs 6.7 for Whites;  $P=.14$ ) as compared with the continued wide disparities in non-WIC participants (21.0 for African Americans vs 7.8 for Whites;  $P<.001$ ).

Although the prenatal WIC participant group and the non-WIC comparison group did not differ in preterm birth percentages, WIC participants were less likely to have extremely preterm deliveries ( $P<.001$ ) and more likely to have moderately preterm deliveries ( $P<.001$ ;

Table 3). African American women who participated in WIC prenatally had fewer preterm deliveries than African Americans who were in the non-WIC comparison group ( $P<.001$ ; Table 4). This result was seen for both moderately preterm deliveries ( $P<.001$ ) and extremely preterm deliveries ( $P<.001$ ). However, White women enrolled in WIC prenatally were slightly more likely to have a preterm birth than were White women in the non-WIC comparison group ( $P=.004$ ). This was primarily because of an increase in moderately preterm deliveries ( $P<.001$ ).

We were not able to assess the trimester of entry into prenatal care. We calculated the trimester of enrollment in WIC services as a loose proxy for the trimester of entry into prenatal care for the WIC group because prenatal providers usually make referrals to WIC and WIC counselors usually make referrals for prenatal care during the first few visits. Only 26.6% of WIC prenatal participants enrolled in WIC during their first trimester, with the majority enrolling in their second (44.4%) or third (29.0%) trimester. The enrollment dates into WIC by trimester are significantly different from the overall rates of entry into prenatal care for residents of Hamilton County, as reported by the Ohio Department of Health Information Warehouse for 2006–2007, with entry into prenatal care in the first trimester at 64.8% ( $P<.001$ ), in the second trimester at 19.9% ( $P<.001$ ), and in the third trimester at 4.0% ( $P<.001$ ), and with 11.4% of deliveries having no or unknown levels of prenatal care.

## DISCUSSION

Infants of African American women who enrolled in the prenatal WIC program in Hamilton County, Ohio, experienced a clinically significant reduction in infant mortality. In addition, within the prenatal WIC group, the disparity in IMR between African American and White infants was markedly narrowed. These findings were analogous to the findings of El-Bastawissi et al. that women enrolled in WIC prenatally were less likely to experience a fetal death,<sup>9</sup> but the lack of effect in White infants was surprising.

We also saw a reduction in preterm births in African American prenatal WIC participants. The decrease in percentage of extremely preterm births in the African American WIC prenatal group compared with the non-WIC group suggest that even if a woman is destined to have a preterm delivery, she may experience a longer gestational period if prenatally enrolled in WIC. This may be an important finding because a decrease in the percentage of preterm births has been associated with a reduction in the IMR<sup>15</sup> as well as reductions in racial disparities in neonatal mortality.<sup>2</sup> This may partially explain the distinct reduction in IMR found among African American women enrolled in the prenatal WIC program. By contrast, the

**TABLE 4—Preterm Birth and Infant Mortality Outcomes in Prenatal WIC Participants and the Non-WIC Comparison Group, Stratified by Race: Hamilton County, OH, 2005–2007**

	Prenatal WIC, No. (Rate %)	Non-WIC Comparison Group, No. (Rate %)	P
Preterm (<37 wk)			
White	357 (10.3)	878 (8.7)	.004 <sup>a</sup>
African American	787 (13.7)	668 (20.0)	<.001 <sup>b</sup>
Moderately preterm (34–36 wk)			
White	278 (8.0)	615 (6.1)	<.001 <sup>a</sup>
African American	559 (9.8)	397 (11.9)	<.001 <sup>b</sup>
Extremely preterm (<34 wk)			
White	79 (2.3)	263 (2.6)	.376 <sup>a</sup>
African American	228 (4.0)	271 (8.1)	<.001 <sup>b</sup>
Infant mortality rate per 1000			
White	23 (6.7)	79 (7.8)	.486 <sup>c</sup>
African American	55 (9.6)	70 (21.0)	<.001 <sup>c</sup>

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

<sup>a</sup>The reference population was White term births ( $\geq 37$  wk) in the WIC population ( $n=3099$ ) and non-WIC comparison group ( $n=9196$ ).

<sup>b</sup>The reference population was African American term births ( $\geq 37$  wk) in the WIC population ( $n=4944$ ) and non-WIC comparison group ( $n=2667$ ).

<sup>c</sup>The reference population was the number of infants surviving 1 year for the selected populations.

results of our study did not show a positive effect on preterm delivery for White women enrolled in WIC prenatally compared with White women in the non-WIC comparison group nor was there an effect on IMR among White women.

The results of previous studies have shown an overall reduction in preterm deliveries to women who enrolled in WIC prenatally.<sup>7,8,16</sup> Among studies that have investigated possible disparate outcomes by race, most have demonstrated reduced preterm deliveries among White prenatal WIC participants.<sup>10</sup> However, the higher rates of smoking among the White prenatal WIC participants in our study may partially explain the lack of a positive effect of WIC participation for Whites. Smokers have an increased relative risk of preterm birth compared with nonsmokers, with a stronger association found for extremely preterm birth.<sup>17,18</sup> Maternal smoking is also associated with a 2- to 3-fold increased risk for sudden infant death syndrome, though it is not always clear whether this increased risk is because of prenatal or fetal exposure to smoke or exposure to secondhand smoke following birth.<sup>18</sup>

Early entry into prenatal care is generally associated with a reduced risk of preterm birth and infant mortality. An analysis of entry into

prenatal care was not possible given our data set, but most women who enrolled in WIC did so in their second or third trimester, whereas most women entering general prenatal care in Hamilton County did so in their first or second trimester. It was interesting that regardless of whether they entered prenatal care later than their non-WIC counterparts, WIC participation was associated with better outcomes, particularly among African Americans.

Several studies have assessed the impact of WIC participation on intrauterine growth retardation, with differing results. Most studies have found that prenatal WIC participation is associated with an increase in birth weight and that this is true within specific racial/ethnic groups.<sup>8,10,17</sup> However, in a multiyear study in New York, New York, Joyce et al. found no relationship between prenatal WIC participation and measures of fetal growth among singletons.<sup>11</sup> Future studies of the potential impact of WIC on intrauterine growth retardation that control for selection bias will improve our understanding of the mechanisms for improved rates of preterm birth and infant mortality.

This study constituted the first effort, to our knowledge, to examine WIC birth outcomes in Hamilton County, Ohio. Because of the

multiyear study period, we were able to obtain a large sample size that allowed us to analyze race-specific birth outcomes associated with WIC participation. Additionally, because we received our data on prenatal WIC participation directly from the Ohio Department of Health, Bureau of Nutrition Services, our study did not suffer from the general under-reporting of WIC participation common to other sources (e.g., birth records, national survey data).<sup>7</sup>

### Limitations

This study had several limitations. Our data contained information on births that occurred in hospitals located within the city of Cincinnati. We did not include the group of prenatal WIC participants who delivered their infants outside the city in our analysis. However, the hospitals located within the city accounted for 73.5% of all deliveries in Hamilton County in 2007, according to an e-mail from K. Hill (project director, Cincinnati Perinatal Outreach Project, April 2009).

Our study lacked a participant-specific measure of income. The poverty characterization by zip code permitted estimates only of income differentials between the WIC group and the non-WIC comparison group. We also did not assess the length of time that women were enrolled in WIC before delivery; therefore, we could not assess a dose–response effect of prenatal WIC participation in our data set. Accounting for the duration of prenatal WIC participation may have increased the observed effect of WIC enrollment on IMR and preterm birth, as we also included women who participated in WIC for only a short time before delivery and thus, arguably, did not receive the full benefit of WIC services in the analysis as WIC participants. Other studies have reported a dose–response relationship such that longer enrollment in WIC prenatally improved birth weight.<sup>10</sup>

Although we attempted to minimize the mismatch in our record linkage protocol, we may not have adequately identified name changes of infants occurring between the date of birth and date of death, which can occur with the submission of name change and paternity affidavits. This may have been a factor associated with our inability to match 302 infant deaths to women in our study population. It

should also be noted that because we excluded multiple gestations, deaths to this high-risk group remained unmatched.

We abstracted maternal behavioral risk factors from birth records, and the accuracy of the self-reported data on the birth records influenced our results. Researchers have documented that self-reported smoking status (including maternal self-report) is generally an underestimate of true smoking status.<sup>19</sup> Interestingly, levels of self-reported alcohol intake during pregnancy can vary in accuracy depending on the type of questions used, the way the data were collected, the period of time referred to during questioning, and the time the questions were asked.<sup>20</sup>

Women who enrolled in the prenatal WIC program may have had other unobserved characteristics that could influence their pregnancy and birth outcomes.

## Conclusions

Results of this study show the strength and efficacy of WIC as a public health intervention that mitigates marked health disparities seen in an African American population. Further, we have identified prenatal smoking as a factor that may have counteracted a beneficial effect of WIC participation in White women. The need for increased emphasis on smoking cessation among WIC participants should be further investigated. Our findings provide a strong rationale to develop greater outreach and education about the WIC program within local communities. ■

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## Contributors

I. Khanani led the writing and synthesized analyses. J. Elam, and R. Hearn programmed the analysis. C. Jones assisted with the study and writing. N. Maseru originated and supervised the study. All authors helped to conceptualize ideas and develop and interpret analyses.

## Human Participant Protection

This project was exempt from institutional review board review because the research examined a public benefit or service program.

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