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Ababa Morke Date

Does WIC Participation During Pregnancy Have an Association with Low Birth Weight and Preterm Birth?

By

Ababa Morke

Master of Public Health

Hubert Department of Global Health

Melissa Young, PhD

Committee Chair

Marcia McCoy, MSW

Committee Member

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Ababa Morke

B.S., University of Minnesota Duluth
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Thesis Committee Chair: Melissa Young, PhD

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Abstract

Does WIC Participation During Pregnancy Have an Association with Low Birth Weight and Preterm Birth?

By Ababa Morke

Introduction: Early access to nutritional services and prenatal care is essential for optimizing birth outcomes. However, evidence on the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and birth outcomes is mixed. We aim to examine the association of WIC participation on low birth weight (LBW) and preterm birth (PTB). We also aim to gain further insight into the association of participation among racially and ethnically different groups in Minnesota.

Methods: The study used birth certificate data from Minnesota for the years 2019-2021, linked with WIC participant information to study the association between WIC participation during pregnancy and LBW and PTB. Logistic regression models were used for the analysis of each outcome. A secondary analysis was conducted to assess these associations stratified among different race/ethnic groups in Minnesota. SAS software was used for statistical analysis, and results were significant if $P<0.05$

Results: From the sample of 46102, prenatal WIC participation for ≥3 months was associated with a 18% reduction of LBW (AOR 0.82; 95% CI 0.76 - .90; P= <0.0001) and a 21% reduction in the prevalence of PTB (AOR 0.79; 95% CI 0.73 – 0.85; P <0.0001). When stratified by race/ethnicity, East African (AOR 0.65; 95% CI 0.50 – 0.85), Hmong (AOR 0.59; 95% CI 0.40 – 0.86), and White (AOR 0.83; 95% CI 0.72 – 0.97) WIC participants showed statistically significant reductions in the prevalence of LBW compared to non-participants. The Asian/NH/PI, Black/African American, Native American, and Hispanic WIC participants lacked statistical significance. For PTB, East African (AOR 0.68; 95% CI 0.52 – 0.87), Hispanic (AOR 0.77; 95% CI 0.65 – 0.91**),** and White (AOR 0.82; 95% CI 0.72 - 0.93) WIC participants showed statistically significant reductions in the prevalence of PTB compared to non-participants. The Asian, Black/African American, Hmong, and Native American WIC participants showed protective odds ratios without the statistical significance.

Conclusion: WIC participation was shown to be protective against PTB and LBW. Increasing WIC enrollment in Minnesota could help reduce the prevalence of PTB and LBW. Our findings may help inform future qualitative studies among Minnesota's racial/ethnic groups to better understand differences in dietary intake, cultural beliefs, or practices that may lead to better outcomes among some groups.

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Chapter 1: Introduction

Among countries with similar Gross Domestic Product, the United States has one of the highest rates of low birth weight (LBW) and preterm births (PTB). These rates have not significantly improved in the last decade. In 2021, 10.5% of U.S. births were preterm and 8.5% were LBW.[1] PTB are live births before 37 weeks of gestation and LBW is defined at weighing less than 2500g at birth.[2,3] Globally, LBW is used as an outcome indicator for the health and development of a child.[3] Children who are born LBW or PTB are at a higher risk for chronic health problems, intellectual and/or developmental delays, and mortality.[2,3] Infants that are LBW are 20 times more likely to die than those who are not.[3] The U.S. has many efforts underway to target these outcomes through nutritional programs administrated through the states.[4]

One of these programs is the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).[5] WIC is a federal program designed to provide low-income pregnant and postpartum women, infants, and children with access to nutritional foods, health care referrals, and nutrition education. The WIC program's goal is to promote health and well-being for low-income families and reduce malnutrition.[5] In 2009, the WIC program was revised to include more nutritious foods and culturally appropriate food choices.[6,23] By increasing access to these services, WIC works to reduce maternal malnutrition and undernutrition during pregnancy that are associated with adverse birth outcomes such as LBW and PTB.[5,6]

The state of Minnesota has one of the highest WIC participation rates, yet the rates of LBW and PTBs have not seen much improvement in the last decade. Instead, the state trends show unchanging or slow increase in PTB rates.[7] The prevalence of PTB rose from 6.8% in 2012 to 7.0% in 2018 among singleton births.[7] LBW rates show a similar slow increase over the years

with a prevalence of 1.7% in 2012 and 1.9% in 2018 among singleton births born after 37 weeks of gestation.[8] PTB is the leading cause of infant mortality and contributes to 20.5% of all infant deaths in Minnesota.[9] Although WIC provides access to prenatal care and education, disparities still exist in accessing these services among racial and ethnic groups.[8] WIC aims to reduce these inequities in access and improve outcomes by targeting malnutrition and prenatal care access among pregnant women and children who are low income.

Research on the effect of WIC on birth outcomes is mixed. Some studies find WIC participation to be associated with better birth outcomes such as higher birthweight and lower rates of PTBs.[10,11,12] In other studies, findings suggest that the associations are not significant.[13,14] While there is limited research on WIC's effect on PTB and LBW among different racial identities, those that do exist suggest that WIC has the greatest effect on improving outcomes for Black and Hispanic groups.[15,16] Testa and Jackson used the Pregnancy Risk Assessment Monitoring System (PRAMS) data to assess adverse birth outcomes and WIC participation by maternal race and ethnicity.[15] Their data showed disproportional rates of PTB between White (7.6%), Hispanic (8.7%), Black (11.8%) births.[15] For LBW, they found similar disparities between White (5.8%), Hispanic (6.6%), and Black (12.1%).[15] Compared to White WIC participants, only Black WIC participants showed a statistically significant 18% reduction in the odds of PTB.[15] Hispanic women had the highest reduction (14%) for LBW and Black women saw a 10% decrease in the odds of LBW compared to White women.[15] Overall, while WIC has been found to have many positive effects on maternal and child health, the evidence is mixed on its effectiveness in reducing PTB or LBW. Further research is needed to strengthen the evidence that does exist.

Purpose Statement

The purpose of this study was to examine whether prenatal WIC participation is associated with birth outcomes among Minnesota Medicaid recipients. The key outcomes were LBW and PTB. Minnesota has a large immigrant population that may have different cultural practices in what they may eat during pregnancy. Since the 2019 WIC revision allowed culturally diverse food options, we believe this may add to benefits. Previous research that examined LBW by race and maternal birthplace found that compared to US born non-Hispanic Black women, women born in Sub-Saharan Africa had 55% reduced risk of LBW ((OR 0.45, 95% CI 0.37–0.56).[17] Similarly, when compared to US born Asian women, women born in Eastern Asia had a 22% reduced risk of LBW (OR 0.78, 95% CI 0.64–0.96).[17] This data will also assess the association of prenatal WIC participation on birth outcomes among Minnesota's racial and ethnic identity groups.

Objectives:

1) To assess the association of prenatal WIC participation with PTB and LBW

2) To assess the association of prenatal WIC participation with PTB and LBW among Minnesota's racial/ethnic groups

Terms/Acronyms & Definitions

Term/Acronym	Definition
Prenatal WIC Participation	Participation in WIC services during pregnancy. In this study, prenatal WIC participation is for ≥3 months.
LBW	Low birth weight: infants weighing less than 2500 grams at birth.
PTB	PTB: infants born alive before 37 weeks of gestation are completed.

Weathering	A physical compounded effect of socioeconomic disadvantage and marginalization over the life course.
Acculturation	Changing one's beliefs, practices, and behaviors in order to assimilate, often to a dominate culture[34]
WHO	World Health Organization
CDC	Centers for Disease Control and Prevention
WIC	The Special Supplemental Nutrition Program for Women, Infants, and Children.

Chapter 2: Background

Adequate prenatal nutrition is an important part of fetal growth and development.[18,19] During pregnancy, the women's body requires greater energy and essential macro and micronutrients such as iron, calcium, and folic acid in addition to vitamins and minerals.[18] Essential organ and nervous system development occurs during the first 1000 days which refers to the period from conception to the second birthday of the child.[20] It is known that a fetus in development adapts to its environment when it senses low nutrient availability, the placenta limits the nutrient getting to the infant because the maternal nutritional needs compete with the fetus.[19] This in turn slows down the development of the fetus and can lead to complications.[19] Inadequate nutrition during pregnancy could lead to developmental defects in the brain or spine, and to poor maternal and child outcomes. Studies have shown that maternal malnutrition during pregnancy is associated with adverse birth outcomes such as LBW, child mortality, and PTB.[21]

The WIC program serves as an intervention for many low-income families. WIC is also provided to children who are medically malnourished. States are given grants that they allocate for supplemental foods, health care referrals, and nutrition education for WIC recipients. WIC recipients must have income at or below 185% of poverty level or qualify for Medicaid[22]. In addition to providing safer and longer pregnancies, WIC claims to be

beneficial for reducing rates of adverse childbirth outcomes such as PTBs and child mortality through its services.[22]

Nationally, WIC coverage for pregnant women in 2019 was 52.3% among those that are eligible.[24] Coverage varies among states and racial groups. The state of Minnesota is among those with the highest coverage rates for WIC. In the same year, the coverage of WIC in Minnesota for women (including those pregnant, postpartum, and postpartum breastfeeding) was 78.5% among those that were eligible.[24] In 2021, Minnesota WIC prenatal participation was rate 67% for pregnant women that received WIC services and 50% of them received services for 3 months or more during their pregnancy. Minnesota's race and ethnic populations are categorized differently for WIC participation due to the large immigrant populations and the groups being different by region and practices surrounding pregnancies. The breakdown of participation rates by race are as follows: Rates of participation for 3 or more months during pregnancy were 45% for Native Americans that participated in WIC, 62% among Hmong, 44% among Black/African Americans, 49% among East Africans, and 49% among Whites.[25]

In addition to providing nutritional services, WIC provides access to prenatal care and education. Access to prenatal care is vital to the health of the infant and mothers during pregnancy. Prenatal visits can help identify risks to healthy pregnancies such as nutritional deficits, infections, and complications. In 2021, 78.3% of pregnant mothers began receiving prenatal care in the first trimester of their pregnancy.[26] Expectant mothers who receive early prenatal care are less likely to have adverse birth outcomes. In 2021, early prenatal care initiation for non-Hispanic white women was 83.2%, non-Hispanic Black was 68.4%, Hispanic 72.5%, and 83.5% for Asian women.[26] While all age groups saw higher rates of prenatal care initiation, disparities exist among low-income women, and some women who are racial or ethnic minorities in the United States.

Despite these services, the rate of adverse pregnancy outcomes has not improved consistently over the past decade. The CDC's national data shows a 4% increase in the rate of PTB and a 3% increase in the rate of LBW between 2020 and 2021.[26] The birth outcomes trends in Minnesota show a similar slow increase in the rate of LBW infants over the last decade.[6] PTB is the second leading cause of infant mortality and contributes to 20.5% of all infant deaths in Minnesota.[9] Infants that survive being born prematurely are at increased risk of experiencing lifelong health issues such as intellectual disabilities, breathing, hearing, vision, and feeding/digestion.[9,2] These place a financial burden for the family and the government in long term disability benefits and medical costs.[9]

While these rates are general averages, disparities exist among races and ethnicities. Income and social disparities create gaps in who can gain access to these services. WIC was developed to increase access to adequate nutrition and antenatal care to pregnant mothers funded by the United States federal government to reduce these inequities in access for those in need. WIC aims to improve the outcomes by targeting malnutrition and prenatal care access among pregnant women and children who are low income.

Existing research

In 2005, Joyce, Gibson, and Colman examined the largest retrospective cohort study with 800,000 births to women on Medicaid in New York (1988 –2001) to assess the effectiveness of WIC participation on birth outcomes.[13] In this study they examined singleton and twin births separately. They also limited the analysis to those who enrolled in WIC by the fourth month of pregnancy to control for the variation in participation length. When looking at the fetal growth measured as (full term LBW and >36 weeks of gestation), they found that prenatal WIC participation did not have association with fetal growth for singleton births.[13] When observed individually, the rates of LBW and PTB were reduced 2.4% points and 3.8% points, respectively among U.S.- born Black WIC participants compared to non-

participants.[13] The researchers believe these findings were exclusive to US born Black women because of the crack- cocaine epidemic that Black WIC non-participants were exposed to at a higher rate.[13] Overall, they found minimal effect of prenatal WIC participation on adverse birth outcomes in New York. [13]

Among San Francisco, California residents, a natural experiment tested the effect of additional supplemental cash vouchers for pregnant WIC participants, to be used for only fruits and vegetables, on birth outcomes.[14] Between 2017 and 2019, 2,200 pregnant participants received vouchers during the regularly scheduled clinic visits and about 75% of them redeemed them at participating stores.[14] Using San Francisco surrounding counties to serve as the control in a quasi- experimental synthetic study to analyze the differences before and after the intervention and adjusting for covariates such as maternal age, race and ethnicity, education, marital status, pre-pregnancy BMI and foreign-born status, the study concluded that there were no differences in birth outcomes among pregnant women who received the cash vouchers compared to those who did not.[14] Researchers suggest that it could be due to the voucher amount not being sufficient to have an effect on the birth outcomes.

In a South Carolina study, Lyudmyla Sonchak used a propensity score matching to balance the covariates between those who participated in WIC and those who did not. She used fixed-effects model estimation to control for time invariant variables by matching the mothers to themselves across multiple pregnancies. This accounts for unobservable maternal characteristics to estimate the effect of WIC on birth outcomes. The unobservable maternal characteristics included one described as the maternal awareness of nutritional benefits of WIC that could lead them to enroll. This selection bias could lead to overestimation of the benefit of WIC.[10] Another characteristic was the women's health before pregnancy. If a woman had multiple health issues that could complicate pregnancy, she could enroll in WIC

to improve her likelihood of a healthy birth outcome thus leading to underestimation of the program's effect.[10]The results suggest that WIC participation is associated with improved birth outcomes, including a reduction in the probability of LBW by 2.5% points, and decrease in the probability of premature birth by 3.4%.[10] The researcher highlights the need for refining our understanding of WIC's impact and assessing its effectiveness with multiple techniques.

Another study that analyzed the rates of LBW and PTB among women enrolled in WIC at different stages of pregnancy and postpartum using the Pregnancy Nutrition Surveillance System (PNSS) data collected by the CDC from 22 states and three tribal governments.[11]The comparison group from this study was those who enrolled in WIC postpartum. When controlled for gestational age, the mean birth weight was 40g higher among prenatal WIC enrollees compared to postpartum enrollees. Compared to postpartum enrollee's rates of LBW and small for gestational age (SGA), rates among prenatal WIC enrollees were 1.7 and 0.7 % lower, respectively.[11] Similarly, those who enrolled during their first trimester had 14g higher mean birth weight compared to those that enrolled during their third trimester, with consistent differences across race and ethnicity.[11]

In a systematic review that examined 20 observational studies comparing maternal and childbirth outcomes among WIC participants and WIC eligible non- participants or comparing outcomes before and after 2009 food package revision, researchers found a moderate strength of evidence that WIC participation is likely associated with lower rates of PTB and LBW.[12] Of the 8 studies that covered birth outcomes, one national cohort study (2011 – 2017, n= 11,148,261 women) found that WIC participation is associated with lower risk of PTB compared to no participation (OR 0.88; CI, 0.86 - 0.87).[12] This was supported with two other studies that had moderate strength of evidence based on assessment of limitations and risk adjustments.[12] This review also found 3 studies that found evidence that

WIC participation was associated with reduced risk of both LBW, with one single state study showing a hazard ratio 0.81 (CI, 0.69 to 0.97) and another cross-sectional analysis showing a 24% risk reduction.[12] In addition, one study among immigrant families showed lower odds of LBW for those who participated in WIC compared to those who did not (OR; 0.79; CI, 0.65 to 0.97).[12]

Racial disparities in WIC research

Racial disparities in the rates of adverse birth outcomes and accessibility to prenatal care are apparent in our national data.[1] Assessing the effect of WIC on these outcomes could inform who needs to be targeted to increase accessibility and reduce these gaps. Limited research has studied the effects of WIC among racial and ethnic identities. Most studies that do stratify by race/ethnicity suggest that WIC has a stronger effect on Black and Hispanic participants.[10,15] In the North Carolina study by Sonchak, they found that Black women who participated had larger reductions in the probability of PTB (3.8 percentage points) and (LBW 3.4 percentage points).[10] This study only looked at limited racial/ethnicity categories: White and Black. In the study by Testa and Jackson using PRAMS data, they found that, compared to White WIC participants, Hispanic WIC participants had a 14% decrease in the odds of LBW (OR .86; CI; 0.77 - 0. 95) and Black WIC participants had a 10% decrease in the odds of LBW (OR .90; CI; 0.82- 0. 99).[15] Researchers in these studies conclude that WIC can be used as a method of reducing racial inequities.[10,15] One limitation that we see in these studies is heterogeneity in these racial groups.[10,15] For instance, Black and Hispanic groups include diverse groups of people who share different social and cultural experiences. The African American Black people are culturally different from Black people in Sub-Saharan Africa and other parts of the world. In a Washington state study that investigated how maternal birthplace is associated with LBW, Wartko et. Al., found lower rates of LBW for Black women born in Sub-Saharan Africa (a (OR 0.58, 95% CI 0.47–0.73), and Asian women born in Eastern Asia (OR 0.68,

95% CI 0.55–0.85), compared to their US born racial counterparts.[17] Since researchers suggest that WIC can be used to mitigate racial disparities that exist in birth outcomes as it has shown it has the highest impact among some racial minorities it is important to examine the association of WIC with LBW and PTB among different racial and ethnic groups.[16]

Chapter II: Methods

Data Source

Data was sourced from the Minnesota Department of Health Vital Records birth certificate data for all births in Minnesota birthing facilities for the three years (2019 - 2021) from the Minnesota Office of Vital Records. This data was then linked with WIC information system data for those who participated in the WIC program. This data does not include Minnesota residents that gave birth in out-of-state facilities. The dataset was de-identified. The Emory University Institutional Review Board determined that this study does not meet the definitions of "human subject research" or "clinical research" and therefore does not require an IRB review.

Sample Selection

To get our study sample, we excluded births that did not use Medicaid as a form of payment, births to non-Minnesota residents, multiple births, missing values for our outcomes of gestational age and birth weight, individuals who had missing/unknown race and education values, individuals who had unknown WIC exposure, and those whose exposure to WIC was for less than 3 months (Figure 1). Individuals who were in the race category "other black" were excluded due to their variability in location of origin which included West African and Caribbean countries. This category was too small to further divide.

Outcome variables

The first outcome was PTB. All births that occurred before 37 weeks of gestation were categorized as preterm and those of 37 weeks or more were considered full term. The second outcome was LBW at delivery. All infants that weigh less than 2500 grams were categorized as LBW and those that weighed 2500 grams or more were considered normal weight.

Exposure

The exposure variable of interest was the receipt of WIC services during pregnancy. The prenatal WIC receipt of services was categorized as ≥3 months or none. Those that received WIC benefits for less than 3 months were excluded from the study to account for any bias, theorizing that late entry into the program may be a marker of high-risk pregnant women or unknown duration of exposure to WIC services.

Covariates

Births were limited to those that used Medicaid as a form of payment to control for income variables. Socioeconomic factors of pregnant mothers included their age at delivery (<20, 20-29, 30-39, ≥40), race/ethnicity (Hispanic all races, Black/African American, East African, Indian American, Asian/PI/NH, Hmong, White), Education (< high school, high school graduate, some higher education, or college graduate), pre-pregnancy body mass index (BMI) (Underweight (<18.5), normal (18.5-24.9), Overweight (25-30), Obese (≥30)). Gestational weight gain was calculated using pre-pregnancy weight and weight at delivery. This was categorized as gaining less weight, more weight, or within recommended gestational weight gain (GWG) limits according to guidelines from the Institute of Medicine (now the National Academy of Medicine). In 2009, a committee of research and medical professionals published a report reexamining GWG and developed guidelines based on maternal pre-pregnancy BMI, maternal outcomes, and child outcomes.[27] They came up with

recommendations by calculating the weight component of an optimal pregnancy such as the placenta, fetus, amniotic fluid, and maternal tissue.[27] The recommendations were such that women who were overweight or obese gained less weight during pregnancy; for Underweight BMI the recommended weight gain was 28 to 40, for normal BMI, 25 to 35, for Overweight BMI, 15 to 25, and for Obese BMI, 10 to 20 pounds.[27] Maternal obstetric characteristics that were included were previous preterm, hypertension, and smoking. We also adjusted for infant sex.

Analysis

We first compared the sample demographic proportions between WIC recipients and non-recipients. WIC recipients were those that received WIC benefits for 3 months or more. We then estimated the association between receipt of WIC services during pregnancy and birth weight using a logistic regression model. We used one model for each outcome to determine the odds ratios. The first outcome of the first model was LBW. We assessed for confounding and interaction using the 10% rule and statistical analysis. Covariates included in the model were age, race, BMI, gestational weight gain, education, urban/rural, maternal obstetric risk factors including previous preterm, hypertension, smoking, and infant sex. The second model was for PTB. The outcome for the second model was PTB. The covariates included in the model are the same as in the first model with the addition of cesarean section.

Secondary Analysis

We also assessed the association between prenatal WIC receipt and race. We checked for confounding and interaction using the 10% rule statistical analysis. We did not find any statistically significant confounding or interacting variables. The model was stratified by race for both outcomes. East African and Hmong were included due to the large populations

that reside in the state of Minnesota. The same models and covariates were used for each of the outcomes.

We used listwise deletion to remove records with missing values for the outcomes in the model. All statistical analysis was performed using SAS software, version 9.4. Analysis was considered significant if $P<0.05$, 95% confidence.

Chapter 3: Results

Table 1 highlights sample characteristics. The descriptive analysis of our study sample of 46102 showed that 54% (25083) of our population participated in WIC for 3 months or more during their pregnancy (Table 1) among those who were WIC eligible. Of the total sample, 6.0% of infants were born LBW and 7.8% of infants were born PTB. Those who participated in WIC prenatally for at least 3 months experienced lower rates of both LBW and preterm delivery at 5.4% and 6.8% respectively compared to those who were WIC eligible but did not participate in WIC during their pregnancy which were 6.9% and 8.9%, respectively. WIC participation was higher among unmarried women at 63.3%. The majority of the sample consisted of women between 20-29 (50.8%) followed by 30-39 years of age (41.3%), with those participating in WIC slightly younger on average. Pre-pregnancy BMI was higher among those who participated in prenatal WIC for 3 months or more. The WIC participants were also more likely to have a lower level of education compared to those that did not participate in WIC prenatally. Maternal health factors such as previous PTB, hypertension, and cesarean section were higher among those who did not participate in WIC. History of ever smoking however, was higher among prenatal WIC participants. Women who participated in WIC were more likely to gain within or under the IOM gestational weight gain recommendation.

Logistic Regression Analysis for LBW

After adjusting for covariates, prenatal WIC participation for 3 months or more is protective against LBW compared to those who did not participate in WIC during pregnancy. The adjusted logistic regression analysis showed prenatal WIC participation for 3 months or more was associated with lower odds of LBW (AOR 0.82; 95% CI 0.76 - .90; P= <0.0001) compared to those who did not participate in WIC (Table 2). Women who were younger than 20 years and those 40 year or more showed greater odds of LBW compared to those that were aged 20-29 (AOR 1.4; 95% CI 1.1 – 1.6; P= 0.0026, AOR 1.5; 95% CI 1.2 – 1.8; P <0.0001 respectively). Compared to college graduates, those who had less than college level education had increased odds of LBW. Women who had a pre-pregnancy BMI defined as obese had lower odds of LBW (AOR 0.69; 95% CI 0.62 – 0.76; P <0 .0001) compared to those who had a normal pre-pregnancy BMI. This was consistent with lower odds of LBW among those that gained more weight than the recommended (AOR 0.58; 95% CI 0.52 – 0.65; P <0.0001)

Table 2.1. Among race and ethnic groups, the Asian/NH/PI and Black/African American groups showed increased odds of LBW infant deliveries (AOR 1.5; 95% CI 1.2 – 1.8; P<0.0001, AOR 1.9; 95% CI 1.7 – 2.2; P <0.0001 respectfully) compared to those who were White. Inversely, those who were East African showed lower odds of LBW (AOR 0.81; 95% CI 0.69 – 0.94; P= 0.006).

Logistic Regression Analysis for PTB

The second logistic regression analysis results showed that prenatal WIC participation for 3 months was protective against PTB compared to those that did not participate. Prenatal WIC participation was associated with lower odds of PTB (AOR 0.79; 95% CI 0.73 – 0.85; P <0.0001). Women who were age 40 or older showed greater odds of PTB compared to those that were aged between 20-29 (AOR 1.3; 95% CI 1.1 – 1.5; P= 0.0075). Compared to college graduates, those who had less than college level education had increased odds of PTB.

Compared with those who gained the recommended weight during gestation, those that gained more than the recommended IOM weight had lower odds of PTB (AOR 0.73; 95% CI 0.66 – 0.80; P <0.0001). conversely, those who gained under the recommended weight experienced higher odds of PTB (AOR 1.6; 95% CI 1.5– 1.8; P<0.0001) **Table 3.1**. Among race and ethnic groups, the Black/African American group showed increased odds of preterm infant birth (AOR 1.3; 95% CI 1.2 – 1.5; P<0.0001) compared to those who were White. Inversely, those who were East African showed lower odds of PTB (AOR 0.57; 95% CI 0.50 – 0.66; P<.0001) compared to White women.

Referencing East Africa in Logistic Regression Analysis

As shown in the supplemental Table 2.2 and Table 3.2, all race/ethnic groups had statistically significant higher odds of PTB when East African group was the reference; Native American (AOR 1.90; CI 1.54 – 2.34), Asian/NH/PI(AOR 2.09; CI 1.70 – 2.57), Black American (AOR 2.27; CI 1.95 – 2.66), Hispanic (AOR 1.82; CI 1.57 – 2.11), and White(AOR 1.75; CI 1.52 – 2.03). The odds of PTB compared to the East African group showed a statistically significant higher odds for Asian/NH/PI, Black/African American, Hispanic, and White groups. The Black/African American group had the highest odds of PTB (AOR 2.27; CI: 1.95 – 2.66) and LBW (AOR 2.41; CI 2.05 – 2.84) compared to the East African group **Table 2.2 & Table 3.2.**

Stratifying by Race/Ethnicity

Figure 2 and Figure 3 demonstrate the odds ratios of LBW and PTB stratified by each race/ethnicity categories. These odds ratio estimates were made by using a logistic regression model for each outcome and race/ethnicity category. The same covariates were adjusted for as in the first two models for both outcomes.

The results of the stratified LBW analysis showed differences in the association of WIC participation and LBW among race/ethnic groups Figure 3. For the East African and Hmong groups, the adjusted logistic regression showed the lowest odds ratios among those who participated in WIC for at least 3 months or more during pregnancy (AOR 0.65; 95% CI 0.5 – 0.85; P =0.0015, AOR 0.59; 95% CI 0.40 – 0.86; P =**0.0073**) compared to those who did not participate in WIC. The analysis also showed prenatal WIC participation for 3 months or more was associated with lower odds of LBW delivery among White women (AOR 0.83; 95% CI 0.72 – 0.97; P =**0.0150**) compared to those that did not participate in WIC. Asian/NH/PI, African American, and Hispanic groups also showed prenatal WIC participation was associated with lower odds of LBW but lacked statistical significance. Among Native American women, prenatal WIC participation was not associated with the prevalence of LBW (AOR 1.12; 95% CI 0.75 – 1.1.69; P=0.5874).

The results of the stratified PTB analysis showed differences in the association of WIC participation and PTB among race/ethnic groups (**Figure 4).** For the East African (AOR 0.68; 95% CI 0.52 – 0.87; P =0**.0023**,) and Hispanic (AOR 0.77; 95% CI 0.65 – 0.91; P =0**.0018)** groups, the adjusted logistic regression showed the lowest odds of PTB among those who participated in prenatal WIC for at least 3 months or more during pregnancy compared to those who did not participate in WIC. The analysis also showed prenatal WIC participation for 3 months or more was associated with lower odds of PTB among White women (AOR 0.82; 95% CI 0.72 – 0.93; P =0.**0015**) compared to those that did not participate in WIC. Non-Hmong Asians, African American, Native American, and Hmong groups also showed that prenatal WIC participation was associated with lower odds of PTB but lacked statistical significance.

Chapter 4: Discussion

This study examined the effect of WIC on two birth outcomes, LBW and PTB among Medicaid births using the Minnesota Vital Statistics records. Our study is in line with previous research that has shown that prenatal WIC participation contributes to reductions in the odds of PTBs and LBW.[12,15,28] After controlling for many covariates, we found a 21% reduction in the odds of PTB among WIC participants compared to those who did not participate. Our study shows slightly more protective effects of WIC participation for PTB (AOR 0.79; CI 0.73 – 0.85) compared to a previous systematic review that analyzed 20 observational studies.[12] One of the studies covered in this review is a cohort study of expectant mothers who delivered live births between January 1, 2011, and December 31, 2017, from the US birth certificate data that was analyzed in 2019. Controlling for the same covariates as our study, this study showed the odds of PTB among prenatal WIC recipients was reduced compared to non-recipients who were on Medicaid 0.87 (CI 0.86 - 0.87).[12,31] Bitler and Currie, found similar trends in a study using PRAMS data from 19 states that contained WIC participation information and maternal and birth outcomes among Medicaid births between 1992 – 199928. While controlling for similar covariates, their study found a 29% reduction in the odds of PTB compared to our 21% reduction for those who participated in WIC.[28] Both of these studies had a larger sample size, use national data, and did not limit the sample to any length of WIC service receipt compared to our single state data that limits participants to at least 3 months of participation.[12,28,31] Our data shows an 18% reduction in the odds of LBW among women who participated in prenatal WIC services compared to those who did not. With an odds ratio of (0.82; 95% CI 0.76 - .90), our data is slightly more conservative than the finding by Bitler and Currie, who saw a 27% reduction in the odds of LBW for women that participated in WIC prenatally.[28] Joyce et al., also found a similar effect

of WIC participation prenatally increased birth weight by 63 grams.[11] Our results are also supported by Lyudmla Sonchak who found comparable results for PTB and LBW.[10]

The results of our study support the notion WIC program has a positive effect on birth outcomes. Our finding of WIC participation being associated with a decreased likelihood of LBW and PTBs is consistent with the goals of the WIC program.[23] These effects could be attributed to the program's services. By providing access to healthy food and nutrition counseling, WIC supports the health of the mother which promotes a healthy fetal development.[19] WIC Provides nutritional food vouchers that improve the nutrition of the mother so that the nutritional status of women during pregnancy affects the development of the fetus. In addition, WIC provides access to prenatal care that could expose risks during pregnancy and help women mitigate them. Our data shows 78% of WIC participants had their first prenatal visit during the first trimester compared to 73% among non-participants. People who initiate prenatal care early have shown reduced rates of adverse birth outcomes.[29]

Our study also aimed to investigate the association of prenatal WIC participation on PTB and LBW among racial/ethnic groups. Our data is similar to current studies that find racial disparities in birth outcomes such as preterm and LBW. When compared to White women, Black/African Americans showed statistically significant higher odds of PTBs (AOR 1.3; CI: 1.2 – 1.5). Both Asian/NH/PI and African American groups showed statistically significant higher odds of low-birth-weight infants compared to White women (AOR 1.5; CI: 1.2 – 1.8) and (AOR 1.9; CI: 1.7 -2.2); respectively. These findings were consistent with previous studies that found infants of Black mothers had the highest risks of PTB and LBW compared to infants of White women with (ARR 2.0; CI: 1.9 - 2.1) and (ARR 1.3; CI: 1.3 – 1.4); respectively.[23] For infants born to Asian women, the risk of LBW was higher compared to White women (ARR 1.3; CI: 1.2 – 1.3).[23,24]

Changing the Reference Group to East African

When we changed the reference group to East African, we found that all race/ethnic groups had statistically significant higher odds of PTBs. Compared to the East African group, the odds of LBW showed a statistically significant higher for Asian/NH/PI, Black/African American, Hispanic, and White groups. It was surprising to see the Black/ African American group having the highest odds of PTB (AOR 2.27; CI: 1.95 – 2.66) and LBW (AOR 2.41; CI 2.05 – 2.84) compared to the East African group. To our knowledge, these two groups (East African and African American) are normally combined when being analyzed in previous research studies which makes it difficult to find a comparable study. These results may be due to the East African groups being newer immigrants to the U.S. and may not have experienced the generationally passed down social and economic effects of marginalization and racism that may have impacted the African American group. Slavery, Jim Crow Laws, and redlining have had a lasting impact on the African American communities that have led them to reside in areas of food deserts, environmental toxin exposures, and unsafe neighborhoods.[32] These effects may have led to weathering among African American women. Weathering is the result of stresses of social disadvantage and discrimination over the life course that contributes to the deterioration of health.[17]

Since previous research studies suggest that WIC can be used to reduce adverse birth outcome disparities among Black and Hispanic infants, we examined the effect of WIC participation on PTBs and LBW for each race/ethnicity separately.[12,15] Our findings show that Black/African Americans who participated in WIC had lower odds of LBW (AOR 0.89; CI: 0.74 – 1.09) while this leans on the protective side, it does not have statistical significance to establish an association. Inversely, East African, Hmong, and White women who participated in WIC showed statistically significant lower prevalence of LBW compared to those who did not participate in WIC. For PTB, our findings showed similar trends for LBW, though all

groups were on the protective side, only East African, Hispanic, and White women who participated in WIC prenatally had statistically significant lower prevalence of PTB compared to those who did not. East African WIC participants had the lowest prevalence of both LBW (AOR 0.65; CI: 0.5 – 0.85) and PTB (AOR 0.68; CI: 0.52 – 0.87). Although the East African group has not been classified in this way before, we believe our findings could be comparable to studies that have classified immigrants from similar regions of Africa. When looking at the risk of LBW and maternal place of origin, Wartko et al., found that black women from Sub-Saharan Africa had a lower risk of LBW (OR 0.58, 95% CI 0.47–0.73).[17] The study authors suggest that institutional racism may have contributed to the observed inequities in outcomes through weathering.[17] East African and Asian communities are both collectivist societies which mean they put the needs of the community before individual needs. This factor could also add to the effect of the WIC program for each of the groups.[33] Therefore, the community social support among these groups surrounding pregnancies could have contributed to the outcomes we observe.[33]

Though our approach was different from previous studies that looked at WIC participation and birth outcomes by race in how we defined the groups, we believe WIC's effect should have been similar to the Asian, Black, Hispanic, and White groups that were comparable. Blakeney et. al's research of participation in WIC during pregnancy and birth outcomes during the 2008 recession resulted in a reduction in the gap between Black and White racial disparity for birth weight.[30] Our study questions that when stratified by race, there is greater risk reduction in adverse birth outcomes for Black Women.[12,15,30,27] The claim that WIC, as an intervention can be used to reduce the adverse birth outcome disparities that exist between minority racial groups and White infants, may not be the case when the Black/African American is further stratified.

Strengths

This study contributes to existing research in many ways. First, we use the most recent data, 2019 -2021 which includes data from the 2009 WIC revision to increase diverse nutritional options. Secondly, our large sample size allows us to gain a deeper understanding of WIC among different racial/ethnic groups that have not been looked at in the same way before. Lastly, we limit WIC participation to those who received WIC services for 3 months or more which accounted for misclassification and reduce variability in participation length.

Limitations

Our study contains multiple limitations 1) This is an observational study and does not show causation. 2) Participants are self-selected, this may lead to differences in characteristics between those who chose to participate versus those who qualify but do not. 3) There may have been inaccuracies in data collection with variables like anemia which we believe were underreported. 4) we do not know the length of time (years) the immigrant women were living in the state. Acculturation from the length of time in the states has been shown in previous studies to lessen the "migrant effect".[34] 5) How often they utilized the WIC services and what variety of foods were purchased could vary among participants, which could affect our results. 6) Data on utilization of the services and enrollment/participation in other programs would have been helpful to control for. 6) We also did not have the data to account for parity which could have biased our results as women who have grand parity are more likely to experience PTB.[35]

Chapter 5: Conclusion

Although our study showed protective associations between WIC participation and LBW and PTB, the mechanisms in which WIC services improve these outcomes could be further strengthened by qualitative research. Gaining community perspectives on the benefits of WIC can help us identify the specific utilization of the services, gaps in existing services, and

cultural beliefs and practices that impact the health of pregnant women. Assessing pregnant women's social support systems could identify differences among the cultural groups that could have impacted our results. In addition, investigating the dietary intake among the different cultural groups could help us identify other unobserved factors that could have biased our studies' findings among some groups.

Chapter 6: Future Implications/Recommendations

Our findings suggest that WIC is associated with reductions in the risk of LBW and PTBs. This highlights the importance of continuing to support and strengthen the WIC program. Future research can investigate ways to improve the effectiveness of the program, such as expanding the coverage and increasing the duration of services. Future recommendations are 1) Increasing Access to the WIC program may help to reduce the risk of LBW and PTBs. Policies and interventions aimed at increasing access to the program, such as outreach efforts and removing barriers to enrollment, can be considered to improve maternal and child health outcomes. 2) Targeting High-Risk Groups: our findings suggest that the protective effect of WIC may be particularly important for certain groups at high risk for PTB and LBW. Future research can investigate ways to better target and tailor the WIC program to the needs of these high-risk groups, such as offering additional services or providing more personalized support. 3) Conducting qualitative research on beliefs and practices among the different groups in Minnesota. 4) Economic Evaluations: Future research conducting economic evaluations to determine the cost-effectiveness of the WIC program in preventing LBW and PTBs. This information can help policymakers make informed decisions regarding resource allocation and program funding.

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Chapter 6: Tables and Figures

Figure 1: Sample selection

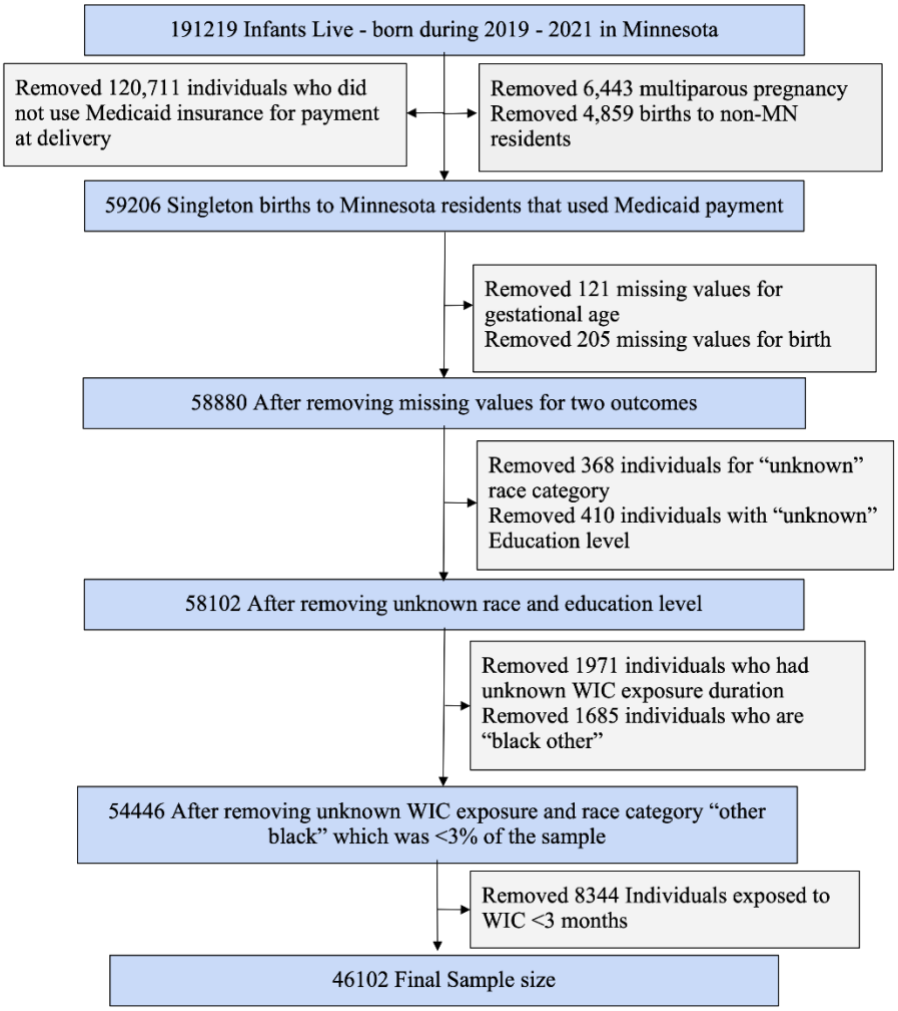

Table 1: Descriptive Statistics of Variables in the Sample of Minnesota WIC Participants and non-participants (2019-2021)

Variable Characteristics	Total Sample n(%) n= 46102	Prenatal WIC ≥3 n= 25083 (54.4)	Prenatal WIC = none n= 21019 (45.6)	P-value
Infant sex				
Male	23500 (51.0)	12736 (50.8)	10764 (51.2)	0.35
Low Birth Weight (<2500g)	2808 (6.1)	1353 (5.4)	1455 (6.9)	<0.0001
Preterm (<37 weeks)	3591 (7.8)	1716 (6.8)	1875 (8.9)	<0.0001
Maternal Variables				<0.0001
Married	17772 (38.5)	9217 (36.7)	8555 (40.7)	
Unmarried	28327 (61.5)	15864 (63.2)	12463 (59.3)	
Age				
<20	1873 (4.1)	1241 (4.9)	632 (3.0)	<0.0001
20-29	23416 (50.8)	13059 (52.1)	10357 (49.2)	
30-39	18981 (41.3)	9826 (39.2)	9155 (43.6)	
40+	1832 (3.9)	957 (3.8)	875 (4.2)	
Pre-pregnancy BMI				<0.0001
Underweight (<18.5)	1762 (3.8)	781 (3.1)	981 (4.7)	
Normal (18.5 - 24.9)	13708 (29.7)	6920 (27.6)	6788 (32.3)	
Overweight (25 - 30)	13421 (29.2)	7369 (29.4)	6052 (28.8)	
Obese (>30)	17211 (37.3)	10013 (39.9)	7198 (34.2)	
Education				
College Grad	4980 (10.8)	1615 (6.4)	3365 (16.0)	<0.0001
Some Higher Ed	15725 (34.1)	7772 (31.0)	7953 (37.8)	
HS Grad	14703 (31.9)	8597 (34.3)	6106 (29.0)	
Less HS	10694 (23.2)	7099 (28.3)	3595 (17.2)	
Race/Ethnicity				<0.0001
Native American	2048(4.4)	1078 (4.4)	970 (4.7)	
Asian/NH/PI	2046 (4.4)	1288 (5.1)	758 (3.6)	
Black(African American)	6331 (13.7)	3197 (12.7)	3134 (14.9)	
East African	6882 (14.9)	4278 (17.1)	2604 (12.4)	
Hispanic all races	8987 (19.6)	5322 (21.2)	3665 (17.4)	
Hmong	2598 (5.6)	1966 (7.8)	632 (3.0)	
White	17210 (37.4)	7954 (31.7)	9256 (44.0)	
Residence				<0.0001
Urban	34904 (75.7)	18150 (72.4)	16754 (79.7)	
Rural	11186 (24.3)	6929 (27.6)	4257 (20.3)	
Maternal history (ref=yes)				0.53
Previous preterm	3074 (6.7)	1649 (6.6)	1425 (6.8)	<.0001
Hypertension	4133 (9.0)	2100 (8.4)	2033 (9.7)	0.53
Cesarean section	12002 (26.0)	6500 (25.9)	5502 (26.2)	0.0055
Ever smoking	7169 (15.6)	4008 (16.0)	3161 (15.0)	
Gestational weight gain[2]				0.11
< IOM	13688 (29.7)	7539 (30.0)	6149 (29.3)	
within IOM	19276 (41.8)	10465 (41.7)	8811 (41.9)	
> IOM	791 (1.7)	233(1.0)	558(2.7)	

1 Prenatal WIC >= 3 months – describes WIC participation during pregnancy for 3 months or more. 2 prenatal WIC = none – describes those who did not participate in WIC during their pregnancy. 2 Gestational weight gain limits based on the Institute of Medicine recommendations per pre-pregnancy BMI

Table 2.1: Logistic Regression Analysis Results for LBW Among Prenatal WIC Participants in Minnesota (2019 – 2021)

Variable Characteristics	Odds Ratio	95% Confidence Limits		p-Value
Prenatal WIC Participation[1] (ref = No WIC participation)	0.82	0.76	0.90	<0.0001
Age (ref =20-29)				
30-39	1.1	1.0	1.2	0.0062
40+	1.5	1.2	1.8	<0.0001
Under 20	1.4	1.1	1.6	0.0026
Marital Status (ref = married)				
Unmarried	1.4	1.3	1.5	<0.0001
Race (ref= White)				
Native American	0.84	0.68	1.0	0.11
Asian/NH/PI	1.5	1.2	1.8	<0.0001
Black (African American)	1.9	1.7	2.2	<0.0001
East African	0.81	0.69	0.94	0.0064
Hispanic all races	1.1	0.95	1.2	0.21
Hmong	0.96	0.78	1.2	0.68
Pre-pregnancy BMI (ref= normal (18.5-25))				
Obese	0.69	0.62	0.76	<0.0001
Overweight	0.92	0.83	1.0	0.14
Underweight	1.6	1.3	2.0	<0.0001
Maternal history (ref=yes)				
Previous preterm	2.9	2.6	3.2	<0.0001
Hypertension	3.7	3.4	4.1	<0.0001
Ever smoking	1.8	1.6	2.0	<0.0001
Education (ref= college graduate)				
High School grad	1.3	1.1	1.5	0.0027
Some Higher ED	1.2	1.0	1.4	0.034
Less than High School	1.1	0.92	1.3	0.30
Residence (ref= urban)				
rural	0.78	0.70	0.87	<0.0001
Infant sex (ref= female)				
Male	0.84	0.78	0.91	<0.0001
IOM weight gain (ref= within)				
< IOM	1.81	1.7	2.0	<0.0001
> IOM	0.58	0.52	0.65	<0.0001

[1]WIC participation – Participation in WIC services for at least 3 months during pregnancy. LBW – infants weighing <2500 grams at birth. Adjusted for covariates: age, race, pre-pregnancy BMI, education, gestational weight gain, marital status, residence, infant sex. Maternal history of preterm birth, smoking, and hypertension.

Table 3.1: Logistic Regression Analysis Results for PTB Among Prenatal WIC participants in Minnesota (2019- 2021)

Variable Characteristics	Odds Ratio	95% Confidence Limits		p-Value
Prenatal WIC Participation[1] (ref = No WIC participation)	0.79	0.73	0.85	<0.0001
Age (ref =20-29)				
30-39	1.1	0.98	1.1	0.16
40+	1.3	1.1	1.5	0.0075
Under 20	1.1	0.87	1.3	0.54
Marital Status (ref = married)				
Unmarried	1.1	1.0	1.2	0.0029
Race (ref= White)				
American Indian	1.1	0.91	1.3	0.37
Asian/NH/PI	1.2	0.99	1.4	0.064
Black (African American)	1.3	1.2	1.5	<0.0001
East African	0.57	0.50	0.66	<0.0001
Hispanic all races	1.0	0.93	1.2	0.51
Hmong	0.83	0.68	1.0	0.055
Pre-pregnancy BMI (ref= normal (18.5-25))				
Obese	0.97	0.89	1.1	0.58
Overweight	1.1	0.97	1.2	0.18
Underweight	1.2	0.97	1.5	0.093
Maternal history (ref=yes)				
Previous preterm	4.2	3.8	4.6	<0.0001
Hypertension	3.1	2.9	3.4	<0.0001
Ever smoking	1.3	1.2	1.5	<0.0001
Cesarean section	2.5	2.3	2.7	<0.0001
Education (ref=college graduate)				
High School grad	1.2	1.1	1.4	0.0044
Some Higher ED	1.3	1.1	1.5	0.0007
Less than High School	1.2	1.0	1.4	0.017
Residence (ref=urban)				
rural	0.90	0.82	0.99	0.030
Infant sex (ref=female)				
Male	1.2	1.1	1.3	<0.0001
IOM weight gain (ref= within)				
< IOM	1.6	1.5	1.8	<0.0001
> IOM	0.73	0.66	0.80	<0.0001

[1]WIC participation – Participation in WIC services for ≥3 months during pregnancy. PTB – births before completion of 37 weeks of gestation. Adjusted for covariates: age, race, pre-pregnancy BMI, education, gestational weight gain, caesarean section, marital status, residence, infant sex. Maternal history of preterm birth, smoking, and hypertension.

Table 2.2: Logistic Regression Analysis Results for LBW Among Prenatal WIC Participants in Minnesota (2019 – 2021)

Variable Characteristics	Odds Ratio	95% Confidence Limits		p-Value
Prenatal WIC Participation[1] (ref = No WIC participation)	0.82	0.76	0.90	<0.0001
Age (ref =20-29)				
30-39	1.1	1.0	1.2	0.0062
40+	1.5	1.2	1.8	<0.0001
Under 20	1.4	1.1	1.6	0.0026
Marital Status (ref = married)				
Unmarried	1.4	1.3	1.5	<0.0001
Race (ref= East African)				
American Indian	1.05	0.82	1.35	0.672
Asian/NH/PI	1.90	1.53	2.35	<0.0001
Black (African American)	2.41	2..05	2.84	<0.0001
Hispanic all races	1.36	1.16	1.56	0.0002
Hmong	1.20	0.96	1.50	0.105
White	1.25	1.07	1.47	0.0046
Pre-pregnancy BMI (ref= normal (18.5-25))				
Obese	0.69	0.62	0.76	<0.0001
Overweight	0.92	0.83	1.0	0.14
Underweight	1.6	1.3	2.0	<0.0001
Maternal history (ref=yes)				
Previous preterm	2.9	2.6	3.2	<0.0001
Hypertension	3.7	3.4	4.1	<0.0001
Ever smoking	1.8	1.6	2.0	<0.0001
Education (ref= college graduate)				
High School grad	1.3	1.1	1.5	0.0027
Some Higher ED	1.2	1.0	1.4	0.034
Less than High School	1.1	0.92	1.3	0.30
Residence (ref= urban)				
rural	0.78	0.70	0.87	<0.0001
Infant sex (ref= female)				
Male	0.84	0.78	0.91	<0.0001
IOM weight gain (ref= within)				
< IOM	1.81	1.7	2.0	<0.0001
> IOM	0.58	0.52	0.65	<0.0001

[1]WIC participation – Participation in WIC services for at least 3 months during pregnancy. LBW – infants weighing <2500 grams at birth. Adjusted for covariates: age, race, pre-pregnancy BMI, education, gestational weight gain, marital status, residence, infant sex. Maternal history of preterm birth, smoking, and hypertension.

Table 3.2: Logistic Regression Analysis Results for PTB Among Prenatal WIC participants in Minnesota (2019- 2021)

Variable Characteristics	Odds Ratio	95% Confidence Limits		p-Value
Prenatal WIC Participation[1] (ref = No WIC participation)	0.79	0.73	0.85	<0.0001
Age (ref =20-29)				
30-39	1.1	0.98	1.1	0.16
40+	1.3	1.1	1.5	0.0075
Under 20	1.1	0.87	1.3	0.54
Marital Status (ref = married)				
Unmarried	1.1	1.0	1.2	0.0029
Race (ref= East African)				
American Indian	1.90	1.54	2.34	<0.0001
Asian/NH/PI	2.09	1.70	2.57	<0.0001
Black (African American)	2.27	1.95	2.66	<0.0001
Hispanic all races	1.82	1.57	2.11	<0.0001
Hmong	1.45	0.17	1.8	0.0008
White	1.75	1.52	2.03	<0.0001
Pre-pregnancy BMI (ref= normal (18.5-25))				
Obese	0.97	0.89	1.1	0.58
Overweight	1.1	0.97	1.2	0.18
Underweight	1.2	0.97	1.5	0.093
Maternal history (ref=yes)				
Previous preterm	4.2	3.8	4.6	<0.0001
Hypertension	3.1	2.9	3.4	<0.0001
Ever smoking	1.3	1.2	1.5	<0.0001
Cesarean section	2.5	2.3	2.7	<0.0001
Education (ref=college graduate)				
High School grad	1.2	1.1	1.4	0.0044
Some Higher ED	1.3	1.1	1.5	0.0007
Less than High School	1.2	1.0	1.4	0.017
Residence (ref=urban)				
rural	0.90	0.82	0.99	0.030
Infant sex (ref=female)				
Male	1.2	1.1	1.3	<0.0001
IOM weight gain (ref= within)				
< IOM	1.6	1.5	1.8	<0.0001
> IOM	0.73	0.66	0.80	<0.0001

[1]WIC participation – Participation in WIC services for at least 3 months during pregnancy. Preterm delivery – births before completion of 37 weeks of gestation. Adjusted for covariates: age, race, pre-pregnancy BMI, education, gestational weight gain, caesarean section, marital status, residence, infant sex. Maternal history of preterm birth, smoking, and hypertension.

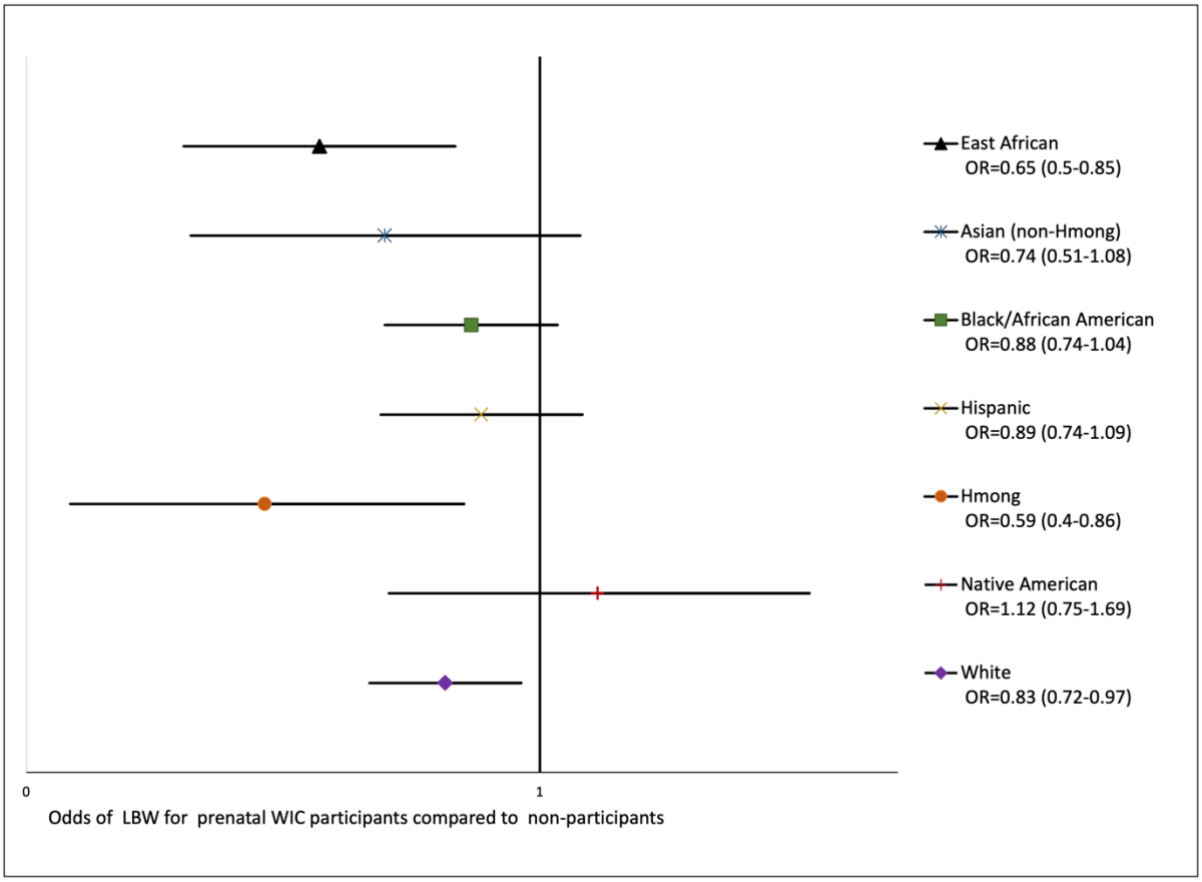

Figure 2: LBW Odds Ratios by Race/Ethnicity/Region among Minnesota Residents (2019 - 2021)

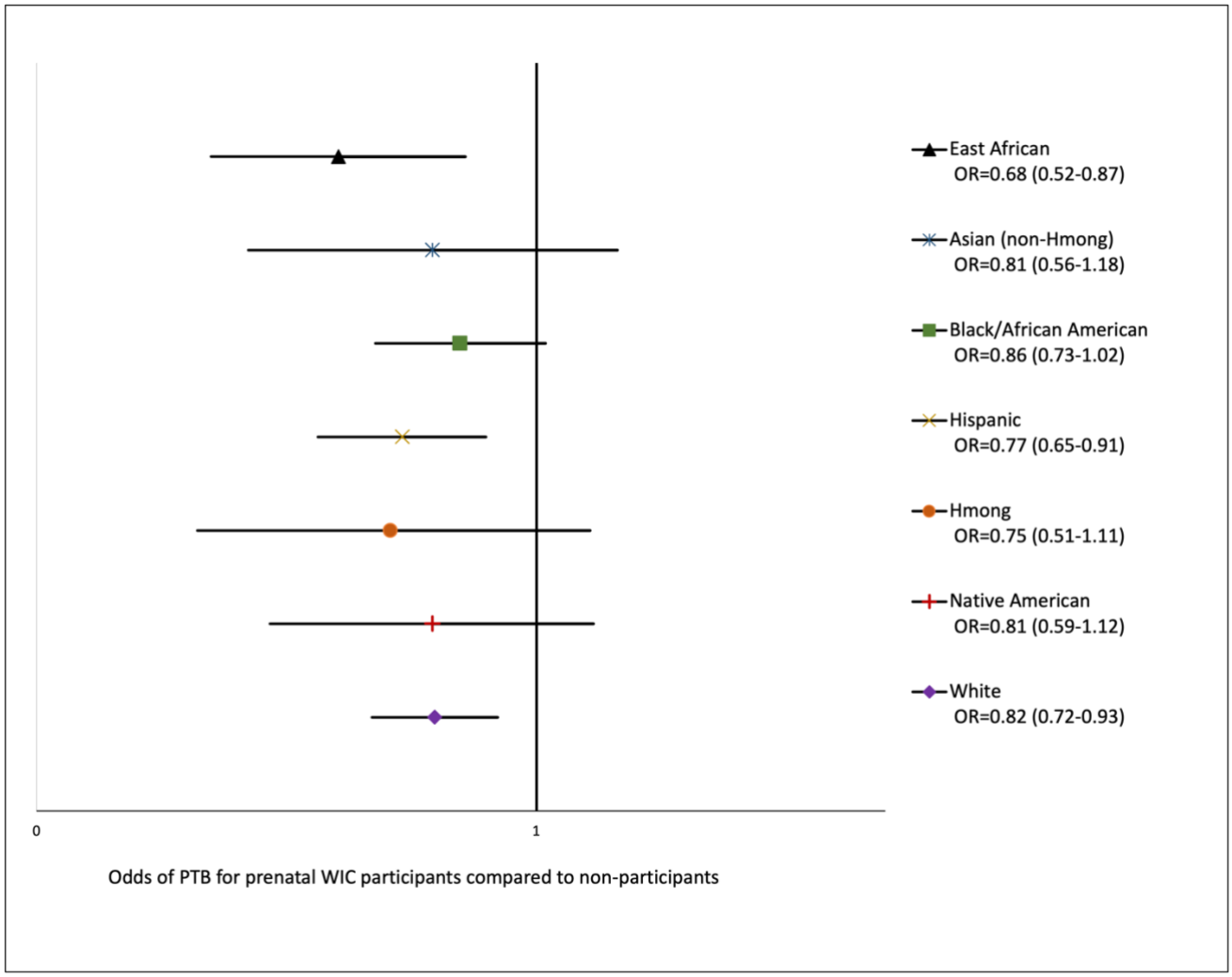

Figure 3: Preterm Odds Ratios by Race/Ethnicity Among Minnesota Residents (2019 - 2021)