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by

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A CRITICAL ANALYSIS OF INTERPREGNANCY INTERVALS AS AN EXPLANATION FOR THE PERSISTENT DISPARITIES IN ADVERSE PERINATAL OUTCOME BETWEEN BLACK AND WHITE WOMEN. Abike T. James, Michael B. Bracken, Ellice Lieberman. Department of Obstetrics and Gynecology, Brigham and Women's Hospital, Boston, MA. (Sponsored by Michael B. Bracken, Department of Epidemiology and Public Health, Yale University School of Medicine).

Short interpregnancy intervals have been repeatedly associated with elevated rates of adverse perinatal outcome. It has been suggested that differences in interpregnancy intervals between the races may explain a significant portion of the racial disparities in perinatal outcome. In a hospital-based cohort of 3978 black and white women whose last pregnancy resulted in a term live birth, the role of interpregnancy intervals in explaining the elevated risk among black women of delivering small for gestational age (SGA) infants was examined using multiple logistic regression models. Preterm delivery and low birthweight were other outcome measures studied in order to compare with prior results in the literature.

Women with intervals of 6 months or less were 3.33 times as likely (95% confidence interval 1.71-6.51) to have an SGA delivery than those with intervals of greater than 24 to 36 months (reference interval). Black women were 1.71 times as likely to deliver an SGA infant (95% confidence interval 1.17-2.49). An elevation in risk of SGA delivery to black women was present at every interpregnancy interval. Black women were also more likely than white women to have short interpregnancy intervals (9.2% of black women had intervals of 6 months or less, compared to 4.8% of white women). After controlling for interpregnancy interval, black women remained at increased risk of SGA delivery (odds ratio 1.67, 95% confidence interval 1.13-2.45). When the socioeconomic variables were placed in the model, the increased risk of SGA delivery among black women disappeared (adjusted odds ratio 0.99, 95% confidence interval 0.61-1.62).

In our analysis, an excess of short interpregnancy intervals among black women did not explain the racial disparities in SGA births. Socioeconomic factors, particularly educational attainment, were more important contributing factors to the racial disparities.

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I. INTRODUCTION

Racial differences in perinatal outcome

Infant mortality remains one of the leading public health concerns in the United States today. Other pregnancy outcomes such as preterm delivery, small for gestational age (SGA) birth and low birth weight (LBW) are associated with an increased risk of infant mortality and have been used as outcome measures in a number of analyses. In their review of the changing pattern of infant mortality in the US, Luke et al. [1] noted the following trends: During the first half of this century, the decline in infant mortality was primarily due to the reduction in post neonatal deaths (2-11 months after birth). From 1950, two-thirds of all infant deaths occurred in the neonatal period, primarily as a result of inadequate birthweight. However, from 1975 through 1985, the incidence of LBW and moderately low birth weight (MLBW) declined by about 9% and 11 % respectively with most of the decline in LBW and MLBW occurring before 1980 (86% and 78% respectively). Although LBW declined for both white and black infants before 1980, the decline was nearly twice as great for white (9%) as for black infants (5%). From 1980 to 1985, the decline in LBW rates was ≤ 1% for both white and black infants. From 1985 to 1988, LBW rates remained the same for white infants but increased by 4.4% for black infants.

Given the aforementioned trends, although national infant mortality rates are declining, black infants continue to have higher rates of infant mortality when compared to

white infants. In 1990-1991, while national infant mortality rates declined 2%, black infants died 2.14 times as often as white infants in 1989.[2] Other studies and statistics have consistently shown that black women are more likely than white to have each of the adverse perinatal outcomes: SGA, LBW and preterm deliveries.

Several maternal risk factors for adverse perinatal outcomes have been identified. The risk factors range from medical complications, to a variety of socioeconomic and sociodemographic factors. However, the extent to which each factor or set of factors explains the disparities remains unclear. An analysis by Eisner et al.[3] of single live births in the United States during 1974, using birth certificate information identified several risk factors for low birth weight delivery. These included previous pregnancy loss, an interpregnancy interval less than six months, a birth out of wedlock, and a pregnancy without prenatal medical care. Interestingly, they found that black mothers were more likely than white mothers to have low birthweight at every level of each factor studied. When Kleinman and Kessel[4] investigated the effects of four socio-demographic maternal characteristics (age, parity, marital status, and education), on rates of very low birth weight (<1500 g) and moderately low birthweight (1500 to 2500 g), they also found that blacks had higher rates than whites for every combination of maternal characteristics. Furthermore, although blacks were much more heavily concentrated than whites in the high-risk sociodemographic groups, this accounted for only part of their much higher rates of very low or moderately low birth weight infants. In fact, in their study, the black:white

ratios of very low birth weight and moderately low birth weight were even larger among women at low risk than among those at high risk.

When Kempe et al. [5] investigated the clinical conditions associated with the disparity in very low birth weight, they found that the higher proportion of black infants with very low birth weight in their analysis was related to an elevated risk of major medical conditions. These were primarily chorioamnionitis or premature rupture of the amniotic membrane, idiopathic preterm labor, hypertensive disorders and hemorrhage. They concluded that comprehensive preventive strategies would be necessary to reduce the disparity in birth weight between black and white women.

Collins and Hammond [6] used 1982-1983 Illinois vital records and 1980 US Census income data to determine the contribution of maternal race to the risk of preterm (<260 days), non-low birth weight (NLBW) infants. In their study, infants were classified as NLBW if their birthweight was > 2,500 g. The unadjusted preterm, NLBW rate was 14% for African Americans compared with 7% for whites (odds ratio 2.4, 95% confidence interval 2.3-2.5). After adjustment for maternal sociodemographic and prenatal care variables (maternal age, parity, education, marital status, census income and prenatal care received), the adjusted odds ratio of preterm, NLBW for African Americans compared with whites was 1.5 (95% confidence interval 1.2-1.7). Hence, even after adjustment, they found that African American women had a 50 percent greater risk of preterm, NLBW delivery than white women. Their study also included comparison of African Americans

to Mexican Americans. They found that African Americans were more likely to have preterm, NLBW births than Mexican Americans (odds ratio 1.7, 95% confidence interval 1.6-1.8). After adjustment for sociodemographic and prenatal care variables, the odds ratio remained elevated at 1.6% (95% confidence interval 1.4-1.8). They suggested that an unidentified factor closely related to African-American race serves as an important fundamental cause of preterm, NLBW delivery.

McGrady et al. [7] reached a similar conclusion through a different study. Using data gathered through a mail survey from graduates of four Atlanta colleges, they compared the risk of preterm delivery and low birth weight among first-born infants of black and white college graduates. In their analysis, the relative risk of preterm delivery for blacks compared with whites was 1.67, while the relative risk of low birth weight was 2.48. The infant mortality ratio for blacks compared with whites was 1.46. Even after adjustment for known risk factors such as socioeconomic status measures, medical complications, behavioral factors, and maternal factors, the odds of low birth weight and preterm delivery were higher for black women (adjusted odds ratios 2.32 and 1.95 respectively).

In contrast, Lieberman et al. [8] conducted a study to investigate risk factors associated with the increased rate of preterm delivery after the spontaneous onset of labor among black women, and arrived at a different conclusion. They found that among the medical conditions examined, only the maternal hematocrit level explained a substantial

proportion of the increased rate of spontaneous preterm delivery to black women. Few studies have examined further the role of the maternal hematocrit in explaining the increased rate of preterm delivery to black women. Lieberman et al. also examined four socioeconomic predictors of preterm delivery: age less than 20 years, single marital status, receiving welfare support and not having graduated from high-school. Their study showed that the presence of any one factor was associated with a moderate increase in the risk of preterm delivery. When the maternal hematocrit and the aggregate number of socioeconomic risk factors was taken into account, they found that essentially all of the racial variation in preterm delivery was explained. In their analysis, the adjusted odds ratio for preterm delivery among blacks was determined to be 1.03 (95% confidence interval 0.9-1.35).

In order to investigate the long term contributions of socioeconomic risk factors to the persistent racial disparities in pregnancy outcome, Foster et al. [9] are conducting an intergenerational analysis among African-American women with sustained high socioeconomic status looking at the effects on low birthweight of successive generations. Their study population is derived from the Meharry Cohort Study comprised of African-American medical students who matriculated at Meharry Medical College between 1958 and 1965. All of the study population graduated from medical/dental school and became economically successful practitioners. The comparison group is derived from a cohort of over 4,000 females, 80% of whom were white. Preliminary findings of the first generation showed 11.5% low birth weight infants among the Meharry students compared to 7.2%

among the white women. Among the second generation, low birthweight frequency declined to 8.3 % for the Meharry cohort as compared to 5.7% for the white infants from national data. The corresponding low birth weight rate for blacks from national data remained as high as 13.2%. At the conclusion of their final analysis, Foster et al. hope to substantiate their hypothesis that in an African-American population with sustained high socio-economic status and comparable risk factors, the birthweight distribution and other reproductive outcomes would be the same as those for comparable US white populations.

In light of the many established maternal risk factors, it would seem intuitive that African-American women, who traditionally are more likely to have lower socioeconomic status, higher rates of teenage pregnancy, and lower educational attainment would be at increased risk for adverse pregnancy outcomes. The question remains however, whether or not socioeconomic status sufficiently explains the observed differences in perinatal outcomes between the races, or whether there are other accountable factors.

The role of interpregnancy interval in perinatal outcome

As early as the 1920's, Hughes and Woodbury of the Children's Bureau revealed that short interpregnancy intervals were associated with an increased risk of perinatal mortality.[10,11] A 1980 edition of Vital and Health Statistics, [12] "*Factors associated with low birth weight*," reported on a continuing study of approximately 59,000 pregnancies. The study found that those infants conceived within 3 months and born within 1 year of a previous full-term pregnancy had lower birth weights on average than a matched group of infants born within 2-5 years of a previous full-term pregnancy. Mothers were least likely to bear a low birth weight baby when the interval between births was 2-4 years (the incidence of LBW for intervals between 2 and 4 years was 4.6% to 4.7%). However, when the current birth was within a year of the previous delivery, the proportion of low birth weight infants was as high as 14.9%.

The maternal depletion hypothesis has been offered as a "physiologic" explanation for the effects of interpregnancy interval on perinatal mortality. This hypothesis states that pregnancies (and periods of lactation), in close succession worsen the mother's nutritional status because of the lack of adequate time for the mother to recover from the physiological stresses of the preceding pregnancy before she becomes subject to the stresses of the next pregnancy. The mother's poor health then increases the risk of preterm birth, intrauterine growth retardation and subsequent fetal loss.[13] There have been other explanations of the effects of short interpregnancy intervals on perinatal mortality that have not had a physiologic basis. Miller [14] reviews the selection hypothesis

in an article on birth intervals and perinatal health. This hypothesis suggests that the increased health risks observed among fetuses conceived shortly after the preceding birth are not attributable to short spacing per se, but to the over representation in this group of women who are at high risk of bearing unhealthy infants for reasons other than short conception intervals. However, multivariate analysis should be able to disentangle the effects of short interpregnancy interval on birth outcome from the effects of potential confounders.

The following studies demonstrate the association between short interpregnancy intervals and higher incidence of adverse perinatal outcome, as well as illustrate the dilemma in assigning causality. In an analysis exploring the relationship between interpregnancy interval with birth weight and gestational age, Brody and Bracken [15] conducted a prospective study controlling for several confounding variables including maternal age, ethnic background, preterm delivery or low birthweight of the prior newborn, and cigarette smoking in pregnancy. Their analysis showed that women who conceived within 9 months of a prior live birth were at increased risk of delivering a low birth weight infant. In particular, those conceiving within 1 to 4 months had a relative risk of 5.70 (95% confidence interval 0.83-39.75) while those conceiving within 5 to 8 months had a relative risk of 3.25 (95% confidence interval 1.02-10.34) of delivering a low birth weight infant when compared to women conceiving 9 or more months after a prior live birth. In their analysis, they found that young maternal age (<20), nonwhite ethnicity, early gestational age and low birthweight of the preceding delivery were also significant

predictors of low birthweight. They also noted that both young maternal age and non-white ethnicity were associated with short interpregnancy intervals.

When Lieberman et al. [16] examined interpregnancy intervals as a risk factor for SGA delivery among women whose last pregnancy resulted in a term live birth, they also found that the greatest risk of SGA birth was amongst the women with the shortest interpregnancy intervals. In their analysis, even after adjusting for multiple confounding factors, women whose interpregnancy interval was 18 or fewer months remained at twice the risk of giving birth to a term SGA infant when compared to women whose interpregnancy intervals were 24 to 36 months. Interestingly, Lang et al. [17] subsequently studied interpregnancy intervals in relation to risk for spontaneous onset of preterm labor, using the same data set and inclusion criteria as Lieberman et al. Lang et al. found that while there was somewhat of an elevated risk of preterm delivery for very short interpregnancy intervals of 3 months or less (adjusted odds ratio = 2.0, 95% confidence interval 0.7-5.4), there was no relation between any of the other intervals and the risk of preterm labor. The combined data from the two studies reinforce the importance of differentiating low birth weight due to preterm birth from that due to intrauterine growth retardation.

A study by Fedrick and Adelstein [18] examined the influence of length of time between pregnancies and outcome of second pregnancy. They found that the most important factors influencing pregnancy spacing were outcome of the preceding delivery,

social class, and maternal age. When these variables had been taken into account, they found that the length of interpregnancy interval had little effect on stillbirth rates. However, even after taking these variables into account, there was a significant excess of neonatal deaths in the groups with interpregnancy intervals less than 6 months.

Erickson and Bjerkedal [19] subsequently examined the association of interpregnancy interval with birth weight, stillbirth and neonatal death using a "pairs of birth" approach. The types of pairs selected for study were first and second births as well as second and third births (in cases where the mother gave birth 3 or more times during the study period), to the same Norwegian mother. They contended that use of the pair approach provides one birth which could possibly have been affected by the length of the interval (the second born of a pair), and one which could not (the first born). In their analysis, they did not find support for a direct association between interpregnancy interval and birth weight. They felt that it was more likely that there were factors associated with a propensity both to have babies at very short intervals and also to have babies of low birth weight. When Klebanoff [20] examined the effect of interpregnancy intervals on the birthweight of the subsequent child, he found that although birthweight did decrease with decreasing interpregnancy intervals, women with short intervals were at relatively high *a priori* risk of having a small infant. He concluded that a short interpregnancy interval is primarily a marker for a woman who is otherwise at high risk, and that modification of this interval alone may be unlikely to have a major impact on low birthweight.

In Miller's [14] analysis, she identified several factors that may potentially confound the relationship between conception intervals and perinatal health. In particular, low educational attainment, previous reproductive loss, young maternal age (<20), out-of-wedlock childbearing, low maternal weight gain during pregnancy* and inadequate prenatal care were all associated with a high incidence of short conception intervals as well as higher rates of preterm and low birth weight births. When she controlled for these factors, there was essentially no change in the relative odds of neonatal mortality among Hungarian infants born less than 12 months after a previous birth (from 1.82 to 1.80). Similarly, these maternal characteristics accounted for approximately only 15% of the excess low birth weight among infants born to mothers with short interpregnancy intervals of less than 12 months. Miller postulated that no risk factor was sufficiently prevalent or strongly enough related to both incidence of short conception and infant health to have a notable confounding effect on the relationship between conception intervals and health. Her conclusions supported the notion that short interpregnancy intervals in and of themselves are risk factors for adverse perinatal outcome. She further suggested that elimination of birth intervals of less than 15 months could be expected to effect as much as a 5-10% reduction in neonatal mortality and low birth weight.

* Miller noted that maternal weight gain was inversely related to both the incidence of short conception intervals and the incidence of low birth weight. However, it is also conceivable that low maternal weight gain is a by-product of short interpregnancy intervals.

Interpregnancy intervals as an explanation for the racial disparities in perinatal outcome

If a short interpregnancy interval is a risk factor for adverse perinatal outcome, and black women are more likely than white women to have shorter intervals, then differences in interpregnancy intervals between the races may explain a significant portion of the disparities in perinatal outcome. This hypothesis was the subject of a study conducted by Rawlings et al. [21] Their study population consisted of only military women in order to minimize confounding by socioeconomic status. They looked at the prevalence of preterm, low birth weight delivery, (defined as birth weight less than 2500 g and delivery before 37 completed weeks), in relation to the interval between pregnancies for white and black women. They found that short interpregnancy intervals were more frequent among black women. They also found that among black women, intervals of less than nine months were associated with a significantly greater prevalence of preterm, LBW delivery. Among the white women in their study, only intervals of less than three months were associated with greater prevalence of preterm, LBW delivery. They reasoned that the relative frequency of short interpregnancy intervals (<9 months) could account for the wide disparity in pregnancy outcome between white and black women.

There were several limitations to their study which were addressed in an editorial by Lieberman. [22] First, the Rawlings study looked at preterm delivery of low birth weight infants. However, when both criteria are met it becomes difficult to compare between races since it has been shown in previous analyses that black infants tend to have lower

birth weight than white infants at each comparative gestational age. Under these criteria, more of the preterm white infants are classified as having a normal outcome (as they are >2500 g), than are black infants. Secondly, attempts to minimize confounding by socioeconomic status by using a women's current status (in Rawlings study all women were military personnel with equal access to health care and income that was only 10% lower for blacks than whites), ignore the woman's lifetime economic status and the contributions that this may have had to her current health status. This is particularly relevant given that compared to white women, middle-class black women are more likely themselves to have been conceived and raised in poverty. As Foster et al. [9] argued, a "newly arrived" black middle class family would not necessarily have the same education, life-style or class stability of a "third generation" middle class black or white family.

In their editorial in response to the Rawlings study, Sheehan and Gregorio [23] sought to replicate Rawlings findings in two data sets: a sample of 5230 inner-city women and a subgroup of 14,777 white and black non-Hispanics from a national sample of women who gave birth during 1988. They found that regardless of which interpregnancy interval or sample was used, the direct effects of race and interpregnancy interval were consistently significant, whereas the interaction effect was not significant. In neither of their analyses was there any suggestion of a differential risk of poor birth outcomes for blacks with short intervals between pregnancies compared to whites with short intervals. Their failure to show that a short interval between pregnancies posed a greater risk for blacks than whites led them to conclude that there was a need to examine this issue further

before sounding an alarm about short interpregnancy intervals posing a greater risk to black women.

This study further examines the relationship between short intervals and adverse perinatal outcome among black and white women with emphasis on the possible role interpregnancy intervals may have in explaining the disparities in perinatal outcome present between the races.

II. STATEMENT OF PURPOSE

The present study was designed in order to critically examine interpregnancy intervals as an explanation for the persistent racial disparities in adverse pregnancy outcome. To do this, the study included: 1) verification that black women were more likely than white women to have SGA, preterm and LBW delivery; 2) evaluation of whether black women were more likely than white women to have short interpregnancy intervals; and, 3) evaluation of whether differences in interpregnancy intervals between the races explained the racial disparities in adverse outcomes among our cohort of women.

While a number of studies have used LBW as their outcome measure, most have not differentiated between short gestation (prematurity) and growth retardation as separate causes of low birth weight delivery. [17] In this analysis, small for gestational age (SGA) delivery was used as the primary outcome since it is a measurable outcome that is distinct from preterm delivery. In addition, preterm delivery and LBW were examined. Most studies using preterm delivery as their outcome measure have not distinguished between preterm birth due to spontaneous labor from that due to complications of pregnancy necessitating medical intervention. For this reason, authors [16,17,24] have advocated restriction of examinations of preterm delivery to women who have had spontaneous preterm labor. In this analysis, the association between interpregnancy intervals and preterm delivery was examined without this restriction. This was done primarily so that we could compare our results with those in the literature. We also examined LBW for the same reason.

The need to understand the relationship between interpregnancy intervals and racial disparities in adverse perinatal outcome remains critical since pregnancy intervals can be influenced through education and modulated by the use of appropriate methods of contraception.

III. METHODS

The data used in this study were collected as part of the Delivery Interview Program (DIP). The interviews were conducted at the Boston Hospital for Women from August 1977 to March 1980. A total of 12,718 women were interviewed and had their medical records reviewed. Data collected included information on medical and obstetric history, course of the current pregnancy, and infant outcome as well as a variety of demographic data.

The cohort of women selected for our analysis consisted of the black and white women whose last birth outcome resulted in a term live birth. The cohort was limited in this way to avoid the potential effect that a previous poor outcome can have on interpregnancy interval. Women may be more likely to have a shorter interpregnancy interval because of a poor last outcome and may also be more likely to have an adverse outcome when the previous outcome was poor. Bakketeig et al. [25] have shown that adverse fetal outcomes tend to be repeated in successive pregnancies.

Preterm delivery was defined as delivery prior to 37 completed weeks of gestation. Low birth weight was defined as birth weight less than 2500 g. Infants were defined as being SGA if their birth weight was less than the tenth percentile for gestational age using the criteria elaborated by Brenner et al. [26] The remaining infants were classified as appropriate for gestational age (AGA). Interpregnancy interval was calculated as the number of months between the women's last delivery of a live infant and the date of the

last menstrual period for the index pregnancy. Since only the month and year of the last live birth was available, we assumed that the date for each infant was the 15th of the given month and year. The interpregnancy intervals were then categorized as follows: 6 or fewer months (<=6 months), more than 6 months but less than or equal to 12 months (>6-12 months), more than 12 months but less than or equal to 24 months (>12-24 months), more than 24 months but less than or equal to 36 months (>24-36 months), more than 36 months but less than or equal to 60 months (>36-60 months), and greater than 60 months (>60 months).

The socioeconomic and demographic variables at the time of the index pregnancy that were examined included mother's level of education, insurance status, marital status and maternal age. Education was considered in four categories: less than high-school education, high-school graduate, some college education, and college graduate. The mother's insurance was also considered in four categories: private insurance, HMO, self-pay, and welfare. Marital status was divided into two categories: the single women category included those women who reported being single, separated, divorced or widowed at the time of the current pregnancy; the "significant other" category included those women who were married or living with a significant other during the current pregnancy. Age was considered in two categories: women less than or equal to 19 years and women who were greater than 19 years.

The analyses using SGA birth as their outcome measure were further restricted to those women whose outcome during the present pregnancy was term. This was done as risk factors for SGA delivery may be different in a preterm population. [16] This restriction excluded 13 premature infants (10 white, 3 black) who were also SGA. We therefore compared term SGA deliveries to term *not* SGA. Too few numbers precluded examination of preterm SGA vs. preterm AGA.

The SAS statistical program was used to perform all analyses. The frequency of SGA births, preterm delivery, LBW birth, interpregnancy intervals and socioeconomic factors were compared for black and white women. The crude odds of adverse pregnancy outcome for black women compared to white women was determined for each outcome measure, and 95% confidence intervals were calculated.

The rate of SGA birth, preterm delivery and LBW birth for each interpregnancy interval was calculated overall and separately for black and white women. In order to illustrate the influence of the size of the groups on the stability of the observed rates, we constructed 95% confidence intervals around each rate. Using the range >24 to 36 months as the reference category, the relative odds of shorter and longer interpregnancy intervals on risk of SGA, preterm and LBW delivery were determined. The period >24 to 36 months was chosen because this was the range of intervals during which both black and white women were least likely to have a poor outcome. The crude odds ratio for delivery of SGA, preterm and LBW infants were determined for each interval and 95% confidence

intervals calculated. After stratification by race, the relative odds of SGA, preterm and LBW delivery within each interpregnancy interval was determined for both black and white women and 95% confidence intervals calculated.

Logistic regression analyses were then performed. Adjustment for the sex of the infant was incorporated into all models in order to limit confounding by this variable (since males have heavier birthweights than females). The crude odds ratios for SGA, preterm and LBW delivery among blacks were determined through a model that included only race and infant sex. Both race and interpregnancy intervals (along with infant sex), were then placed into a logistic regression model to determine how much of the increased risk of SGA, preterm or LBW delivery in black women was explained by interpregnancy intervals. In the models, each interpregnancy interval other than the referent category was represented by a separate dichotomous (indicator) variable in the logistic regression.

A series of regressions were then performed based upon the original model, now adjusting for the various socioeconomic variables including education, maternal age, medical insurance and marital status. In order to rule out the possibility of residual confounding by maternal age, we also examined logistic regression models in which maternal age was considered in multiple categories. For the SGA analysis, the categories were: <= 19 years, >19 to 24 years, >24 to 29 years, and >29 years. The preterm and LBW analyses had the following categories: <= 19 years, >19 to 24 years, >24 to 29 years, >29 to 34 years, and >34 years. In each case, the adjusted odds ratio was

unchanged from the adjusted odds ratios resulting from consideration of age in two categories (<=19 and >19 years). Hence, the only results presented and discussed are those in which age was considered in two categories. For each logistic regression analysis odds ratios and 95% confidence intervals were calculated.

IV. RESULTS

Small for Gestational Age (SGA) analysis

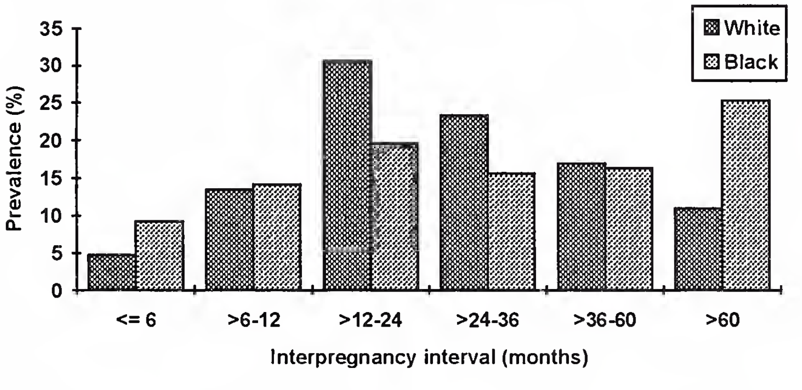
The inclusion criteria were met by 3978 women whose previous pregnancy resulted in a term live birth and whose current pregnancy was also term. 3400(85.5%) of the women were white and 578(14.5%) were black. Of the 3978 women, 168 gave birth to SGA infants for an overall rate of 4.2% SGA births. Table 1 presents the socio-economic and demographic factors included in the analyses and their frequency distribution within our cohort. As shown, black women were more likely than white women to be of lower socioeconomic status (chi-square analysis yielded p-value 0.001 for every socioeconomic factor). Most notably, only 27 % of black women had some college or higher education, as compared to 73% of white women. Similarly, while 56% of black women were on welfare, only 6% of the white women were on welfare. And, 71% of white women had private insurance compared to 23% of black women.

Table 1. Demographic characteristics according to race (SGA cohort)

	Black (n=578) (Percentages)	White(n=3400) (Percentages)	Chi-square (P-Value)
Education			0.001
College Grad	10.0	47.9	
Some College	17.0	25.7	
High-school Grad	40.7	20.1	
Less than High-school	32.2	6.3	
Insurance			0.001
Private	23.5	71.0	
HMO	14.0	16.4	
Self-Pay	7.0	7.0	
Welfare	55.7	5.6	
Marital Status			0.001
Single	45.6	3.3	
Significant Other	54.4	96.7	
Maternal Age			0.001
<= 19 years	8.9	0.8	
> 19 years	91.2	99.2	

Figure 1 shows the frequency distribution of interpregnancy intervals for black and white women.[1] Black women demonstrated a slight shift towards shorter intervals when compared with white women. 9.2% of black women had interpregnancy intervals of 6 months or less as compared with 4.8% of white women. However, the percentage of black women with interpregnancy intervals between 6 and 12 months was similar to white women (black women 14.2% , white women 13.5%). Interestingly, black women were also more likely than white women to have the "longer" interpregnancy intervals with 25.3% of black women in the >60 months range as compared to 11% of white women.

Figure 1. Frequency distribution of interpregnancy intervals by race (SGA cohort)

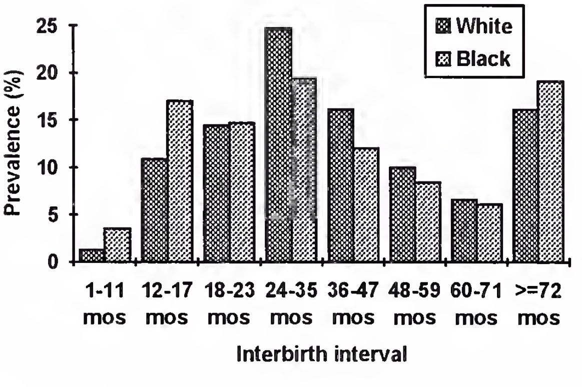


In order to compare our frequency distribution to that of national data, we plotted the frequency distribution of interpregnancy intervals by race from our data using birth to birth intervals. This graph of interbirth intervals was then compared to a similar graph of national data from the United States, 1991 (Figure 2 and 3).[27] The national data computed interbirth intervals as the interval from the mother's last live birth to the date of the present birth. A similar computation was made using the DIP data. Figure 2 is a

[1] Refer to Appendix A for the data used to generate graphs.

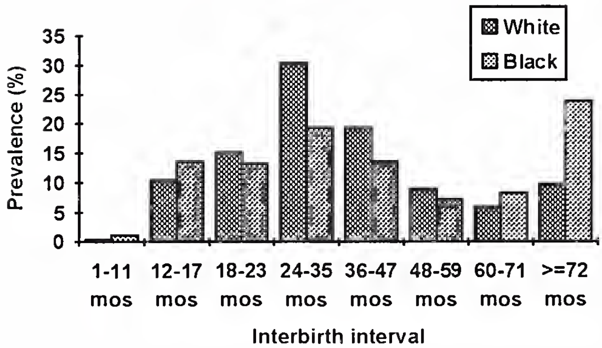
graph of interbirth intervals by race using national data.[2] Figure 3 is the graph of interbirth intervals by race using the DIP data. In general, the frequency distribution of interbirth intervals from the national data was similar to ours. However, there was a higher percentage of both black and white women in the short interval range (1-11 months) among the national data: the percentage of black and white women with interbirth intervals between 1-11 months was 3.5% and 1.3% respectively from the national data, compared to percentages of 1.1% and 0.4% from our cohort . Nevertheless, the ratio of the percentages for blacks to white during this interval was the same for both samples (2.69:1 from national data, 2.75:1 our data). The other notable difference was in the long intervals of >72 months. The ratio of black to white women with these long intervals was 2.46:1 in our cohort compared to 1.19:1 in the national data.

Figure 2. Frequency distribution of interbirth intervals using national data



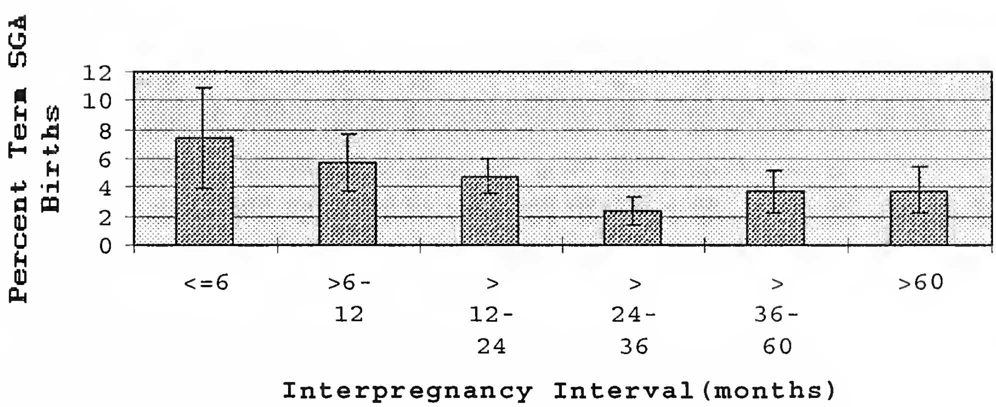
[2] National data excludes women who had plural deliveries and those who did not state their interval between pregnancies.

Figure 3. Frequency distribution of interbirth intervals by race using DIP data



In general, the rate of SGA birth was inversely related to the interpregnancy interval until about 24 months after which the rate of SGA births increased as the interval increased (Figure 4). The highest rate of SGA births occurred in women who had an interpregnancy interval of 6 or fewer months with 7.4% of these women giving birth to SGA infants. The rate was lowest when interpregnancy intervals were >24 to 36 months with only 2.4% of the women with intervals in this range giving birth to SGA infants.

Figure 4. Percent term SGA births (95% confidence intervals) by interpregnancy interval



Error bars = 95% confidence intervals

Using the optimal intervals of >24 to 36 months as the reference point, the relative odds of having an SGA birth at all the other intervals were determined. The results are presented in table 2. The odds ratios in the first column (A) are unadjusted for potential confounding. These results showed a 3.33 increase in risk of SGA delivery for women with intervals of 6 or fewer months (95% confidence intervals 1.71-6.51). This risk decreased as the interval increased, but remained significantly elevated with intervals of >12 to 24 months showing a 2 fold increase in risk of SGA birth. At the other end of the spectrum, women having children with intervals greater than 60 months also had an increased risk of SGA with odds ratio 1.77 and 95% confidence intervals 1.29-2.43. Column B shows the odds ratio and confidence intervals after adjusting for confounding by race, and socioeconomic variables including education, maternal age, insurance and marital status. Except for the >12 to 24 month interval range, adjustment for confounding reduced the risk of SGA delivery in each interval. However, the relative odds after adjustment remained significantly elevated for the shorter interpregnancy intervals. Women with intervals of six or fewer months were 2.74 times as likely to have an SGA delivery than women with intervals >24 to 36 months (95% confidence interval 1.39-5.42) after adjusting for confounding. Even at intervals of >6 to 12 months, the risk of SGA delivery was significantly elevated after adjustment for confounding (odds ratio 2.33, 95% confidence interval 1.32-4.14). For the interval range >12 to 24 months, adjustment hardly affected the risk of SGA delivery (odds ratio 2.08, 95% confidence interval 1.24-3.48). The increased risk previously seen associated with the longer intervals (>60

months) was no longer statistically significant after adjusting for confounding (odds ratio 1.51, 95% confidence interval 0.80-2.84).

Table 2. Crude and adjusted odds ratios (OR) for SGA delivery by interpregnancy interval (IPI)

Interpregnancy interval	Crude OR*(95% CI)* (A)	Adjusted ϕ OR (95%CI) (B)
<=6mths	3.33(1.71-6.51)	2.74(1.39-5.42)
>6-12mths	2.50(1.42-4.40)	2.33(1.32-4.14)
>12-24mths	2.06(1.24-3.44)	2.08(1.24-3.48)
>24-36mths	1δ	1δ
>36-60mths	1.60(0.88-2.88)	1.52(0.84-2.75)
>60mths	1.77(1.29-2.43)	1.51(0.80-2.84)

* OR odds ratio, CI confidence intervals
ϕ Adjusted for infant sex, race, education, maternal age, insurance and marital status
δ Reference group

Results of the prevalence of adverse perinatal outcome by race (Table 3) demonstrated that black women were at increased risk of SGA delivery compared with white women. Among the cohort of women, the prevalence of SGA birth to black women was 6.4%, compared to a rate of 3.8% for white women.

Table 3. Prevalence of SGA, preterm birth and LBW by race

	Black n(Percentages)	White n(Percentages)
Gestational Size [3]		
SGA	37(6.4%)	131(3.8%)
AGA	541(93.6%)	3269(96.2%)
Length of Gestation		
Preterm	49(7.8%)	148(4.2%)
Term	578(92.2%)	3400(95.8%)
Birth Weight		
LBW	45(7.2%)	153(4.3%)
BW>=2500 g	582(92.8%)	3395(95.7%)

[3] Cohort restricted to pregnancies resulting in a term live birth.

When the odds ratio (adjusted only for infant sex) was determined, it showed that black women had an increased risk = 1.71 (95% confidence interval 1.17-2.49) of delivering an SGA infant (Table 4). When interpregnancy interval was added to the model, the odds ratio was relatively unchanged (odds ratio 1.67, 95% confidence interval 1.13-2.45). However, once socioeconomic variables were factored into the model, the odds ratio began to decline. In particular, controlling for education alone lowered the odds ratio from 1.67 to 1.16 (95% confidence interval 0.76-1,78). When the additional socioeconomic variables were placed in the model, (maternal age, insurance and marital status), the increased risk of SGA delivery previously seen associated with black women disappeared (odds ratio 0.99, 95% confidence interval 0.61-1.62). Table 4 presents the odds ratios for SGA birth and 95% confidence intervals for each of the models.

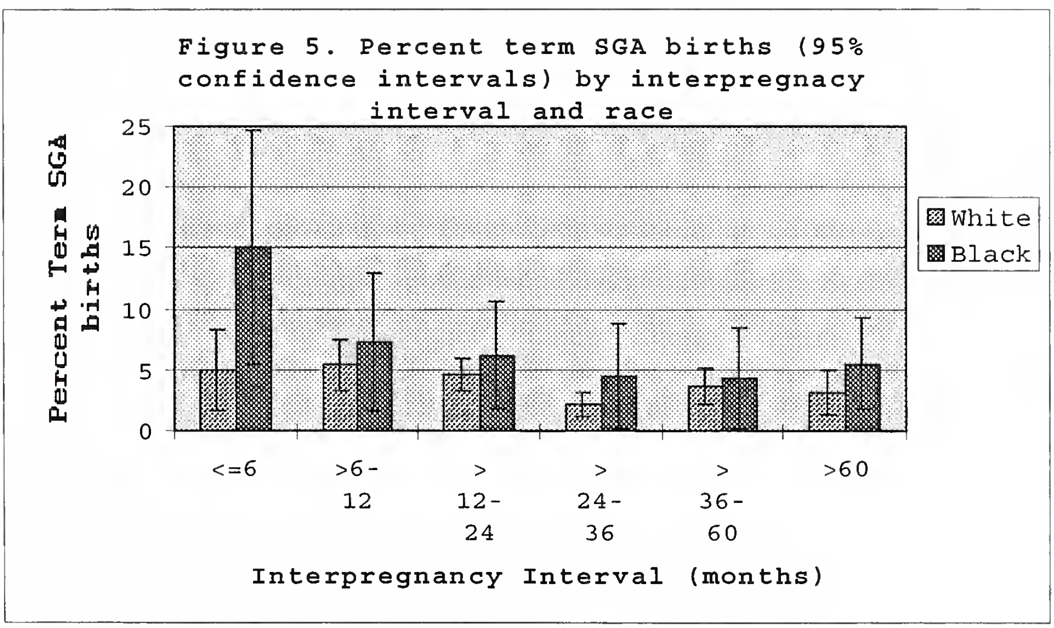
Table 4. Odds ratios for SGA birth and 95% confidence intervals derived from logistic regression models

Model	Odds Ratio	95% Confidence Intervals
Race, infant sex		
Black	1.71	1.17-2.49
White	1δ	
Female	1.76	1.28-2.42
Male	1δ	
Race, IPI, infant sex		
Black	1.67	1.13-2.45
White	1δ	
<=6mths	3.08	1.57-6.04
>6-12mths	2.42	1.37-4.27
>12-24mths	2.07	1.24-3.46
>24-36mths	1δ	
>36-60mths	1.56	0.86-2.81
>60mths	1.50	0.80-2.82
Female	1.77	1.29-2.43
Male	1δ	

Model	OR	95% Confidence intervals
Race, IPI, education, infant		
sex	1.16	0.76-1.78
Black	1δ	
White		
	2.76	1.40-5.45
<=6mths		
>6-12mths	2.27	1.29-4.02
>12-24mths	2.05	1.22-3.42
>24-36mths	1δ	
>36-60mths	1.52	0.84-2.75
>60mths	1.47	0.78-2.76
College grad	1δ	
Some college	0.79	0.49-1.25
High-school grad	1.43	0.95-2.16
<High-school	2.46	1.53-3.98
Female	1.77	1.29-2.44
Male	1δ	
Race, IPI, maternal age, education, method of payment, marital status, infant sex		
Black	0.99	0.61-1.62
White	1δ	
<=6mths	2.74	1.39-5.42
>6-12mths	2.33	1.32-4.14
>12-24mths	2.08	1.24-3.48
>24-36mths	1δ	
>36-60mths	1.52	0.84-2.75
>60mths	1.51	0.80-2.84
Maternal age<=19	0.94	0.40-2.18
Maternal age>19	1δ	
College grad	1δ	
Some college	0.80	0.50-1.27
High-school grad	1.44	0.94-2.19
<High-school	2.35	1.32-4.17
Private	1δ	
welfare	1.25	0.68-2.27
HMO	1.02	0.65-1.61
Self-pay	0.49	0.22-1.10
Single	1.11	0.60-2.04
Significant other	1δ	
Female	1.80	1.30-2.47
Male	1δ	

δ Reference group

Lastly, the frequencies of SGA birth by interpregnancy interval were compared between the races. Figure 5 is a graph of the rate of SGA delivery at each range of interpregnancy intervals for both black and white women. Confidence intervals were included. For every interval, black women had a higher rate of SGA births. The increased odds was particularly evident at short intervals (6 months or fewer). In this range, black women were three times as likely as white women to have an SGA infant. Even at the optimal interval range of >24 to 26 months, black women were twice as likely as white women to have a SGA birth. However, given the small numbers in the cells of the shortest intervals (163 (4.8% of the white women) , 53 (9.2% of the black women)), the confidence intervals were widest at this point (See Appendix A for actual data).



Error bars = 95% confidence intervals

The relative odds of SGA births by interpregnancy interval, were also determined for each race using >24 to 36 months as the reference interval. The results of this analysis, depicted in table 5, showed that at interpregnancy intervals of six or fewer months, black women had a nearly four fold increased odds of SGA delivery than did black women with intervals >24 to 36 months. White women on the other hand had a two fold increased risk when their interpregnancy intervals were short (<=6 months). This contrast in relative risks between the races was not evident at any of the other intervals.

Table 5. Relative risk of SGA birth by race and interpregnancy interval

Interpregnancy Interval	Black OR * (95% CI) *	White OR (95%CI)
<=6mths	3.82(1.09-13.4)	2.35(1.00-5.55)
>6-12mths	1.70(0.462-6.24)	2.62(1.40-4.91)
>12-24mths	1.42(0.40-5.01)	2.21(1.26-3.88)
>24-36mths	1δ	1δ
>36-60mths	0.96(0.23-3.94)	1.73(0.90-3.31)
>60mths	1.25(0.36-4.26)	1.51(0.71-3.19)

* OR odds ratio, CI confidence intervals
δ Reference group

Using the rate of SGA delivery among black women at each interval and the sample distribution of white women at corresponding intervals, we calculated an "adjusted SGA rate" for black women for each interval (table 6). We then determined a hypothetical overall adjusted SGA rate for black women based upon the sample distribution for white women (sum of black SGA rate times sample distribution of white women at each interval). The calculated overall adjusted rate at 6% remained close to the unadjusted rate of SGA births among black women (6.4%). It was still considerably higher than the rate of SGA births among white women (3.8%).

Table 6. Calculation of the adjusted SGA rates for black women using the sample distribution for white women.

Inter pregnancy interval	Black sample distribution	Black SGA rate	White sample distribution	White SGA rate	Black SGA rate X white prevalence
<= 6 mths	0.092	0.151	0.048	0.049	0.007248
>6-12 mths	0.142	0.073	0.135	0.054	0.009855
>12-24 mths	0.195	0.062	0.305	0.046	0.01891
>24-36 mths	0.156	0.044	0.233	0.021	0.010252
>36-60 mths	0.163	0.043	0.169	0.037	0.007267
>60 mths	0.253	0.055	0.110	0.032	0.00605
				Adjusted SGA rate =	**0.0596**

Preterm analysis

Our analysis using preterm delivery as the outcome measure included the 4175 black and white women, whose previous pregnancy had resulted in a term live birth. 627 (15%) of these women were black, and 3548 (85%) were white. Of the 4175 women, 197 gave birth to a preterm infant for an overall rate of 4.7%. The distributions of the socioeconomic and demographic factors were essentially equivalent to those seen in the SGA analysis (table 7).

Table 7. Demographic characteristics according to race(Preterm and LBW cohorts)

	Black (n=627) (Percentages)	White (n=3548) (Percentages)	Chi-square (P-Value)
Education			0.001
College Grad	10.7	47.4	
Some College	17.2	25.4	
High-school Grad	40.1	20.6	
Less than High-school	32	6.6	
Insurance			0.001
Private	23.1	71	
HMO	13.5	16	
Self-Pay	7.1	7.1	
Welfare	56.3	5.9	
Marital Status			0.001
Single	45.9	3.4	
Significant Other	54.1	96.6	
Maternal Age			0.001
<= 19 years	8.9	0.9	
> 19 years	91.1	99.1	

The frequency distribution of the interpregnancy intervals for black and white women in the preterm delivery cohort mirrored that of the SGA cohort (Fig 6). Black women showed the slight shift towards shorter intervals when compared to white women. 9.1% of black women had interpregnancy intervals of 6 months or less compared to 4.9% of white women.

Figure 6. Frequency distribution of interpregnancy intervals by race (Preterm and LBW cohort)

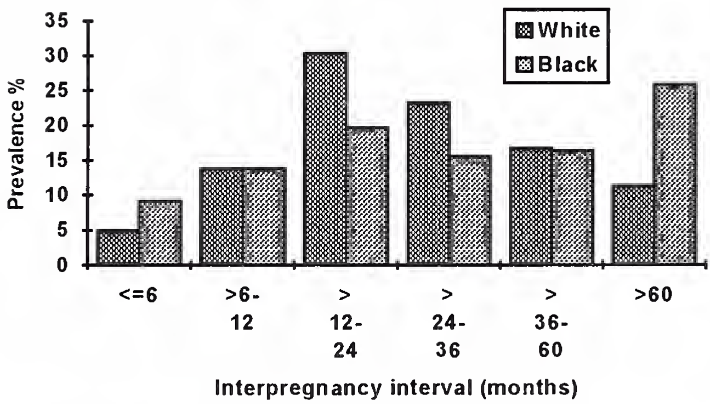
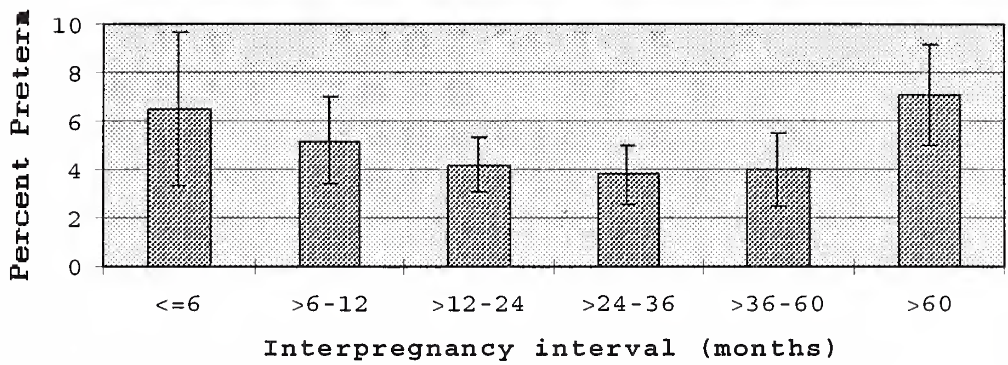


Figure 7 shows the prevalence of preterm delivery by interpregnancy interval. In general, the rate of preterm delivery was inversely related to the interpregnancy interval until the >24 to 36 month interval category, after which the rate of preterm delivery increased as intervals increased. In this analysis, the highest rate of preterm delivery occurred in women who had the longest intervals of 60 months or greater (7.1%). The next highest rate of preterm delivery occurred among women with short intervals of 6 months or less (6.5%). The lowest rate of preterm delivery occurred during the >24 to 36 month intervals (3.8%).

Figure 7. Percentage of women with Preterm delivery (95% confidence interval), by interpregnancy interval



Using the interval range >24 to 36 months as the reference point, the crude and adjusted odds ratios were determined in order to assess the relative odds of preterm delivery at each interval compared to the reference interval. These results are presented in Table 8. In the crude model, women with the shortest interpregnancy intervals had an increased risk of preterm delivery with odds ratio = 1.75. However this value was not statistically significant (95% confidence interval 0.94-3.26). The increased risk generally decreased substantially as intervals increased. However, at the longest intervals of >60 months, there was a statistically significant increased risk of preterm delivery (odds ratio 1.93, 95% confidence interval 1.21-3.08). Adjustment for confounding by infant sex, race, and socioeconomic variables reduced the odds ratio at the shortest interpregnancy interval to 1.37 (95% confidence interval 0.73-2.60). At the longest intervals, the odds ratio was reduced to 1.65 which was still statistically significant (95% confidence interval 1.02-2.67).

Table 8. Crude and adjusted odds ratios for preterm delivery by IPI

Interpregnancy interval	Crude OR*(95%CI)* (A)	Adjusted ϕ OR (95%CI) (B)
<=6mths	1.75(0.94-3.26)	1.37(0.73-2.60)
>6-12mths	1.39(0.85-2.30)	1.21(0.73-2.00)
>12-24mths	1.10(0.61-1.70)	1.06(0.68-1.65)
>24-36mths	1δ	1δ
>36-60mths	1.02(0.61-1.70)	0.96(0.57-1.60)
>60mths	1.93(1.21-3.08)	1.65(1.02-2.67)

* OR odds ratio, CI confidence intervals
ϕ Adjusted for infant sex, race, education, maternal age, insurance and marital status
δ Reference group

Black women had a higher prevalence of preterm delivery (7.8%) than white women (4.2%) (Table 3). The crude and adjusted odds ratios were determined to assess the relative odds of preterm delivery for black women compared to white women (Table 9). The crude odds ratios showed that black women were 1.95 times as likely to have a preterm delivery than white women (95% confidence interval 1.39-2.72). Adjustment for interpregnancy interval alone reduced the odds ratio to 1.77 with 95% confidence interval 1.26-2.5. Additional adjustment for socioeconomic variables including education, maternal age, insurance and marital status lowered the odds ratio to 1.28 (95% confidence interval 0.83-1.98). Once again, education was the socioeconomic variable that reduced the odds ratio the most, from 1.77 to 1.41. Table 9 shows the odds ratios and 95% confidence intervals for each of the logistic regression models examined in this analysis.

Table 9. Odds ratios for preterm delivery and 95% confidence intervals derived from logistic regression models.

Model	Odds Ratio	95% Confidence Intervals
Race, infant sex		
Black	1.95	1.39-2.72
White	1δ	
Female	0.95	0.72-1.27
Male	1δ	

Model	Odds ratio	95% confidence interval
Race, IPI, infant sex		
Black	1.77	1.26-2.50
White	1δ	
<=6mths	1.59	0.85-2.98
>6-12mths	1.35	0.82-2.23
>12-24mths	1.10	0.71-1.71
>24-36mths	1δ	
>36-60mths	0.99	0.59-1.65
>60mths	1.71	1.07-2.75
Female	0.96	0.72-1.28
Male	1δ	
Race, IPI, educ, infant sex		
Black	1.41	0.97-2.04
White	1δ	
<=6mths	1.44	0.76-2.70
>6-12mths	1.27	0.77-2.10
>12-24mths	1.08	0.70-1.69
>24-36mths	1δ	
>36-60mths	0.95	0.57-1.59
>60mths	1.62	1.01-2.61
College grad	1δ	
Some college	1.09	0.72-1.64
High-school grad	1.71	1.17-2.49
<High-school	1.84	1.14-2.96
Female	0.97	0.73-1.29
Male	1δ	
Race, IPI, maternal age, education, method of payment, marital status, infant sex		
Black	1.28	0.83-1.98
White	1δ	
<=6mths	1.37	0.73-2.60
>6-12mths	1.21	0.73-2.00
>12-24mths	1.06	0.68-1.65
>24-36mths	1δ	
>36-60mths	0.96	0.57-1.60
>60mths	1.65	1.02-2.67
Maternal age<=19	1.64	0.76-3.56
Maternal age>19	1δ	
College Grad	1δ	
Some college	1.03	0.68-1.56
High-school grad	1.56	1.05-2.31
<High-school	1.31	0.77-2.36

Private	1δ	
welfare	1.32	0.77-2.27
HMO	0.46	0.26-0.81
Self-pay	1.31	0.79-2.19
Single	0.93	0.54-1.62
Significant other	1δ	0.79-2.19
Female	0.96	0.72-1.28
Male	1δ	

δ Reference Group

The relative odds of preterm delivery after stratification by race were then examined. Figure 8 is a graph of the rate of preterm delivery at each interval by race. In this analysis, we did not see the remarkable discrepancy in preterm delivery between black and white women at the shortest interpregnancy intervals (<= 6 months) apparent in the SGA analysis. However, from interpregnancy intervals greater than 12 months, black women were much more likely than white to have preterm deliveries at every range.

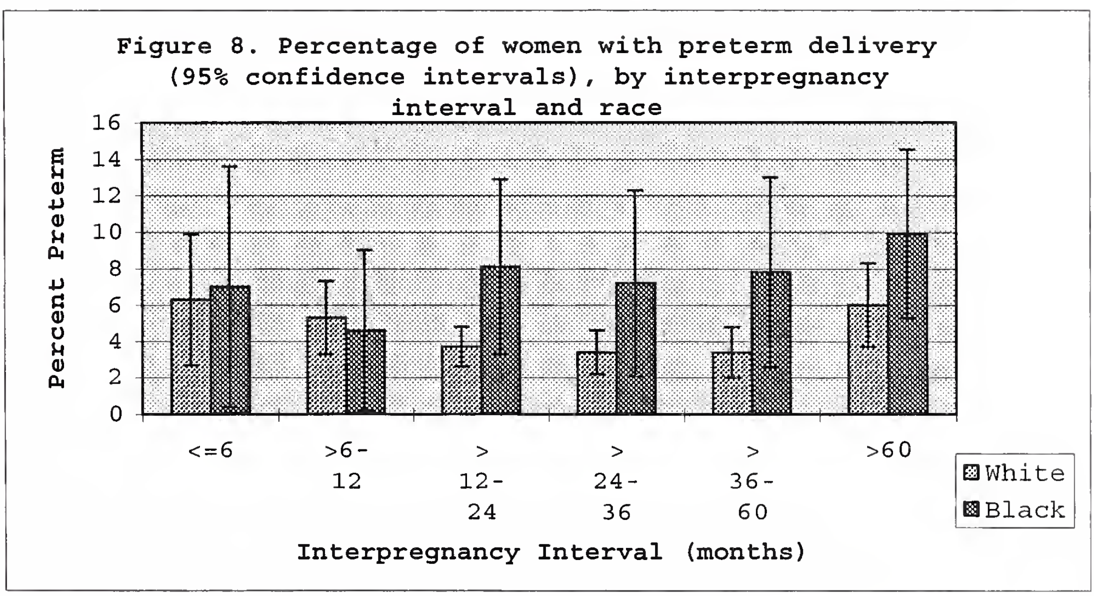


Figure 8. Percentage of women with preterm delivery (95% confidence intervals), by interpregnancy interval and race

Error bars = 95% confidence intervals

Comparison of the distribution of percent preterm delivery by interpregnancy intervals for black and white women showed that while there was an association between short interpregnancy intervals and preterm delivery among the white cohort, this effect was not noted among the black cohort. Table 10 presents the odds of preterm delivery at each interval, relative to the referent interval of >24 to 36 months, for black and white women. Short intervals of 6 months or less only conferred an increased odds of preterm delivery to white women (odds ratio 1.91, 95% confidence interval 0.93-3.91). For black women, the odds ratio at intervals of 6 months or less was 0.97, 95% confidence interval 0.27-3.27. Long intervals (>60 months) conferred an increased risk of preterm delivery to both races, but was only significant among white women (odds ratios and 95% confidence intervals for black and white women were 1.41 (0.56-3.56) and 1.81(1.03-3.17) respectively).

Table 10. Relative odds of preterm delivery by interpregnancy interval and race

Interpregnancy Interval	**Black OR * (95% CI) ***	**White OR (95%CI)**
<=6mths	0.97(0.27-3.27)	1.91(0.93-3.91)
>6-12mths	0.63(0.18-2.22)	1.60(0.93-2.76)
>12-24mths	1.14(0.42-3.11)	1.09(0.67-1.79)
>24-36mths	1δ	1δ
>36-60mths	1.09(0.38-3.14)	0.99(0.55-1.77)
>60mths	1.41(0.56-3.56)	1.81(1.03-3.17)

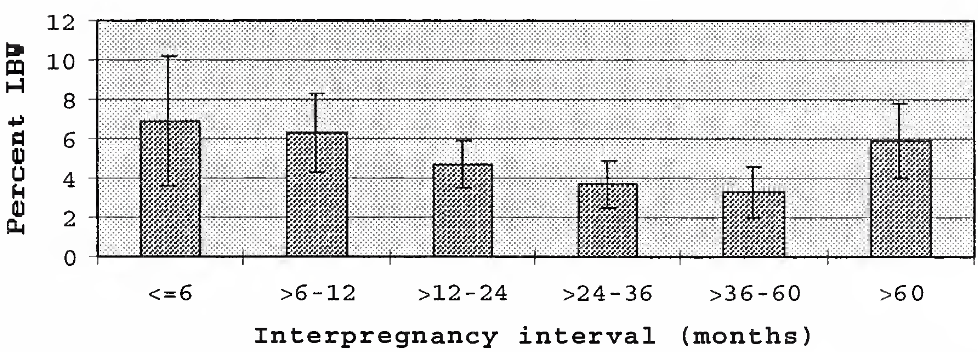
* OR odds ratio, CI confidence intervals
δ Reference group

Low birthweight (LBW) analysis

The cohort of women selected for the LBW study was identical to the preterm delivery cohort. It comprised of 4175 women, whose previous pregnancy resulted in a term live birth. 627 (15%) of these women were black, and 3548 (85%) were white. Of the 4175 women, 198 gave birth to a low birthweight infant for an overall rate of 4.7%.

Figure 9 shows the prevalence of low birthweight birth by interpregnancy interval. In general, the low birthweight rate was inversely related to the interpregnancy interval until the >36 to 60 months interval range, after which the rate of increased for intervals greater than 60 months. In this analysis, the highest rate of low birth weight deliveries occurred in women with interpregnancy intervals of 6 months or less (6.9%). The lowest rate of low birth weight delivery occurred to women with intervals >36 to 60 months (3.3%). Longer interpregnancy intervals of > 60 months also had high rates of low birth weight delivery (5.9%).

Figure 9. Percent LBW births (95% confidence intervals), by interpregnancy interval



Error bars = 95% confidence intervals

In order to remain consistent, we continued to use the >24 to 36 month interval range as the reference interval. The low birth weight rate during this interval range was 3.7%. We then determined crude and adjusted odds ratios in order to assess the relative risk of low birth weight delivery at each interval when compared to the reference interval. These results can be seen in Table 11. In the crude model, women with the shortest interpregnancy intervals had a statistically significant increased risk of low birth weight delivery compared to women with intervals > 24 to 36 months (odds ratio 1.95, 95% confidence interval 1.05-3.60). The odds ratios decreased as length of interpregnancy intervals increased, however, at the longest intervals of 60 months or greater, there was once again a statistically significant increased risk of low birthweight delivery (odds ratio 1.65, 95% confidence interval 1.01-2.69). Adjustment for confounding by infant sex, race, and socioeconomic variables reduced the odds ratio at the shortest interpregnancy interval to 1.57, 95% confidence interval 0.84-2.93. At the longest intervals, adjustment reduced the odds ratio to 1.40, 95% confidence interval 0.85-2.31.

Table 11. Crude and adjusted odds ratios for LBW by interpregnancy interval

Interpregnancy interval	Crude OR*(95%CI)* (A)	Adjusted ϕ OR (95%CI) (B)
<=6mths	1.95(1.05-3.60)	1.57(0.84-2.93)
>6-12mths	1.75(1.08-2.84)	1.58(0.97-2.57)
>12-24mths	1.30(0.84-2.01)	1.27(0.82-1.97)
>24-36mths	1δ	1δ
>36-60mths	0.85(0.49-1.47)	0.77(0.44-1.33)
>60mths	1.65(1.01-2.69)	1.40(0.85-2.31)

* OR odds ratio, CI confidence intervals
ϕ Adjusted for infant sex, race, education, maternal age, insurance and marital status
δ Reference group

Table 3 shows that Black women had a higher prevalence of low birth weight (7.2%) when compared with white women (4.3%). Crude and adjusted odds ratios were then calculated to assess the relative risk of LBW delivery for black women compared to white women (Table 12). The crude odds ratios showed that black women were 1.73 times as likely to deliver a low birth weight infant as white women (95% confidence interval 1.22-2.44). Adjustment for interpregnancy interval alone had minimal effect, (odds ratio 1.63, 95% confidence interval 1.15 -2.32). Additional adjustment for socioeconomic variables including education, maternal age, insurance and marital status lowered the odds ratio to 1.07, 95% confidence interval 0.69-1.67. Adjustment for education alone lowered the odds ratio from 1.63 to 1.17, 95% confidence interval 0.8-1.7. Table 12 shows the odds ratios and 95% confidence intervals for each of the models examined in the LBW analysis.

Table 12. Odds ratios for LBW birth and 95% confidence intervals derived from logistic regression models.

Model	Odds Ratio	95% Confidence Intervals
Race, infant sex		
Black	1.73	1.22-2.44
White	1δ	
Female	1.51	1.13-2.02
Male	1δ	
Race, IPI, infant sex		
Black	1.63	1.15-2.32
White	1δ	
<=6mths	1.81	0.97-3.35
>6-12mths	1.71	1.05-2.77
>12-24mths	1.30	0.84-2.01
>24-36mths	1δ	
>36-60mths	0.83	0.48-1.43
>60mths	1.49	0.91-2.46
Female	1.52	1.14-2.03
Male	1δ	

Model	Odds Ratio	95% Confidence Intervals
Race, IPI, educ, infant sex		
Black	1.17	0.80-1.70
White	1δ	
<=6mths	1.56	0.84-2.91
>6-12mths	1.56	0.96-2.54
>12-24mths	1.27	0.82-1.97
>24-36mths	1δ	
>36-60mths	0.78	0.45-1.35
>60mths	1.39	0.84-2.30
College Grad	1δ	
Some college	0.96	0.63-1.48
High-school grad	2.02	1.39-2.93
<High-school	2.35	1.48-3.73
Female	1.53	1.15-2.05
Male	1δ	
Race, IPI, maternal age, educ method of payment, marital status, infant sex		
Black	1.07	0.69-1.67
White	1δ	
<=6mths	1.57	0.84-2.93
>6-12mths	1.58	0.97-2.57
>12-24mths	1.27	0.82-1.97
>24-36mths	1δ	
>36-60mths	0.77	0.44-1.33
>60mths	1.40	0.85-2.31
Maternal age<=19	0.76	0.32-1.80
Maternal age>19	1δ	
College grad	1δ	
Some college	0.95	0.61-1.46
High-school grad	1.96	1.34-2.88
<High-school	2.20	1.28-3.77
Private	1δ	
welfare	1.35	0.80-2.29
HMO	0.55	0.33-0.93
Self-pay	0.67	0.36-1.25
Single	0.85	0.49-1.49
Significant other	1δ	

δ Reference group

Figure 10 is a graph of the prevalence of LBW for each interpregnancy interval stratified by race. The results from this analysis were similar to that of the preterm delivery analysis. At the short interpregnancy intervals (<= 6 months) there is essentially no difference in the increased risk of low birthweight between black and white women. At intervals ranging from greater than 6 months to 24 months, as well as the longer interpregnancy intervals of >60 months, black women were more likely to have a low birthweight infant than white women. Table 13 depicts the relative odds of LBW births for each interpregnancy interval by race. When stratified in this manner, longer interpregnancy intervals confer a greater risk of LBW delivery on black women than do intervals of six months or less. Among white women, the reverse was true, with intervals of six months or less showing the greatest risk of low birthweight (odds ratio 1.95, 95% confidence interval 0.98-3.89).

Figure 10. Percent LBW births by interpregnancy interval and race

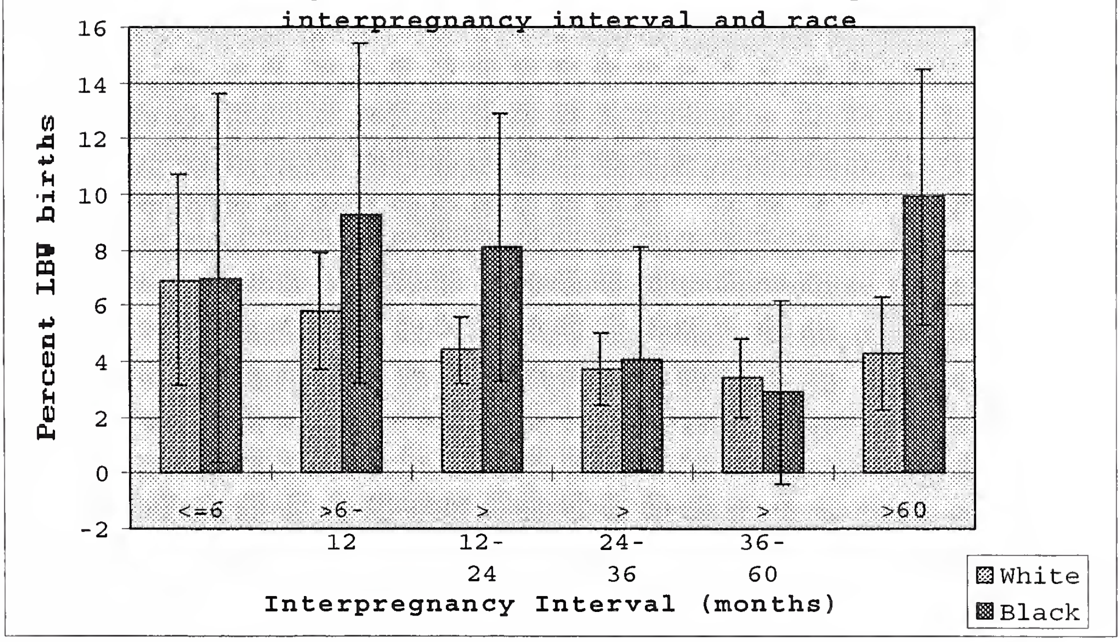


Table 13. Relative odds of LBW birth by interpregnancy interval and race

Interpregnancy Interval	Black OR * (95% CI) *	White OR (95%CI)
<=6mths	1.75(0.42-7.31)	1.95(0.98-3.89)
>6-12mths	2.38(0.69-8.22)	1.61(0.95-2.73)
>12-24mths	2.06(0.62-6.77)	1.20(0.75-1.92)
>24-36mths	1δ	1δ
>36-60mths	0.70(0.15-3.23)	0.92(0.52-1.63)
>60mths	2.55(0.83-7.86)	1.17(0.64-2.15)

* OR odds ratio, CI confidence intervals

δ Reference group

V. DISCUSSION

Previous observations that black women have a nearly two fold increased risk of SGA delivery than do white women were verified in this analysis. Furthermore, analysis of the frequency distribution of interpregnancy intervals showed that black women were more likely than white women to have shorter interpregnancy intervals, especially intervals of six months or fewer. And, the greatest risk of SGA delivery to women after a previous full term live birth occurred at the shortest interpregnancy intervals of 6 months or less. The question asked however, was whether these differences in interpregnancy intervals explain the racial disparity in SGA births.

From the results of the logistic regression models, there was no support for inter pregnancy interval as an explanation for this disparity. The increased risk of SGA delivery for black women was essentially unchanged after adjusting for interpregnancy interval (odds ratio after adjusting for interpregnancy interval 1.67, 95% confidence interval 1.13-2.45). However, when socioeconomic variables were included in the model, the increased risk of SGA delivery for black women disappeared (odds ratio 0.99, 95% confidence interval 0.61-1.62). On the other hand, the increased risk of SGA delivery to black and white women with intervals of six or fewer months remained significantly elevated (odds ratio 2.74, 95% confidence interval 1.39-5.42) despite adjustment for the same socioeconomic factors. These results suggest that while a short interpregnancy interval is an independent risk factor for SGA delivery, it does not account for the

disparities in the rates of black and white SGA birth. The racial disparities in SGA deliveries in this cohort were predominantly explained by socioeconomic factors.

The interesting caveat in our analysis, however, was the finding that at the short intervals of six months or less, black women were much more likely to have SGA infants than were white women (four fold increased risk for black vs. two fold increase for white women). Similarly, Rawlings et al.[21] found that whereas an interpregnancy interval of <9 months was associated with significant increased rates of preterm delivery among the black women in their study, only intervals of <3 months were associated with increased adverse outcome among the white women. Berkowitz and Hatch[28] pointed out in a letter to the editor in response to Rawlings findings, that the presence of a racial difference associated with even one interpregnancy interval suggests that short intervals themselves cannot wholly explain the racial disparities in pregnancy outcomes. This observation is particularly relevant to our study where at every interval, the risk of SGA birth was higher among black women compared to white women.

Given the small numbers in intervals of six months or less in our study and the subsequent wide confidence intervals around the rates of SGA birth, the noted effect at short intervals may have been due to chance. However, if these findings were not due to chance, they suggest that short intervals may have a different effect on the races even though they do not explain the disparities seen. As noted in the results section, when the SGA rates for blacks were adjusted to the distribution of white women at each interval,

the overall adjusted SGA rate of 6% for black women was similar to the unadjusted black SGA rate of 6.4%. The questions remaining are why do black women have higher SGA rates at every interval, and why do short intervals differentially affect black and white women?

Winkvist et al. [29] offered a new more practical conceptual framework for the maternal depletion theory incorporating nutrition and child bearing patterns. Their definition was as follows: (1) Maternal depletion is a condition that should be evaluated over one reproductive cycle at a time. (2) It is characterized by a negative change in maternal nutritional status during the reproductive cycle, and the change is more negative the longer the periods of potential depletion and/or the shorter the periods of potential repletion. (3) It most likely occurs only among women with marginally inadequate food intake, because these are the women for whom the balance between the potential depletion and potential repletion phases has an important functional role. In 1976, findings from their case control study led Ferraz et al. [30] to also suggest that the effect of short intervals on the risk of intrauterine growth retardation is mediated through maternal nutritional status. In their study, short interpregnancy intervals (six months or less) were more frequently observed in women with postpartum body weight of less than 45 kg (31.1%), than in women weighing 50 kg or more (18.9%). Our findings are perhaps easier explained within these frameworks. In our cohort, black women tended to have lower socioeconomic status than white women and hence were more likely to have a poorer baseline nutritional status. They would, therefore, under this framework, be potentially

more susceptible to the effects of depletion and inadequate repletion. This effect may have been exacerbated at the shortest intervals. Further investigation needs to be conducted in this area. If it is indeed the case that at the very short interpregnancy intervals black women are particularly susceptible to adverse outcomes, prevention efforts may be directed appropriately.

The analysis of interpregnancy interval and preterm delivery in general showed trends similar to those seen in the SGA analysis. However, the detrimental effect of short interpregnancy intervals on preterm delivery was of a lower magnitude than the effect on SGA birth. Interestingly, long interpregnancy intervals (>60 months) had the greatest risk of preterm delivery. Unlike the SGA analysis, in the preterm analysis there was an association between short interpregnancy intervals and increased risk of preterm delivery among the white cohort that was not evident among the black cohort.

These findings may be attributable to the small number of black women with an interpregnancy interval of 6 months or less. However, the information also suggests that the mechanism by which interpregnancy intervals affect risk for preterm delivery may be different than the mechanism governing its effect on SGA delivery. Lang et al. [17] had similar results when they analyzed interpregnancy interval and risk of preterm labor. They reasoned that short interpregnancy intervals, often reported as a risk factor for low birth weight , more plausibly have their effects related to the intrauterine growth of infants rather than to factors related to the spontaneous onset of premature labor.

Our analysis showed a greater disparity in preterm delivery between the races than was seen with SGA births. Once again the disparity was not explained by interpregnancy intervals. Although socioeconomic factors explained a substantial portion of the disparities, there remained an odds ratio of 1.28 after adjustment for all the socioeconomic factors. Issues such as parity and medical conditions which were not examined in this study but have been identified as risk factors for preterm delivery in other studies may have played a role here.

The results of the LBW analysis were not as striking as the SGA and preterm analyses. This is most likely because SGA and preterm delivery are more specific outcomes, whereas LBW as an outcome does not distinguish between low birth weight secondary to intrauterine growth retardation, and/or preterm delivery. Interestingly, in our LBW analyses, their was essentially no difference in the rate of LBW delivery between the races at the shortest intervals (<=6 months). At intervals ranging from greater than 6 months to greater than 24 months and > 60 months, the risk of LBW was higher for black women than white. The variation in our results at the short intervals is most likely attributable to the small numbers in these cells. Once again, black women had a higher prevalence of LBW births compared to white women. And, differences in interpregnancy intervals did not explain the disparities in LBW birth. The LBW analysis also showed that socioeconomic factors explained most of the disparity in the rate of LBW delivery between the races.

In the literature, disparities in low birth weight between the races have lead many authors to propose the use of race-specific norms. Kleinman and Kessel [4] argued that the persistence of large racial differences, even among the low-risk group of their population, raises the question of whether there is an inherent biologic difference in "normal" birth weight. Wilcox and Russell [31] proposed that there are different birth-weight "norms" for blacks and whites, in much the same way as there are different birth-weight norms for male and female infants. They proposed examining the perinatal mortality of two populations (blacks and whites), by plotting each weight-specific mortality curve relative to its own birthweight distribution. Kleinman and Kessel pointed out that a difference in norms need not lead to differences in mortality. They cite the fact that although female infants have lower mean birth weights than male infants, they do not have higher perinatal mortality. [32]

Other authors have highlighted nutritional status as playing an important role in the racial differences. Luke and Murtaugh [33] point out that race may be a confounding factor between dietary intake, nutritional status, and the rate and pattern of weight gain during pregnancy and birth weight, preceding or compounding other medical factors leading to very low birth weight. Similarly, Collins and Hammond [6] speculated that a deterioration in the health of US-born African American women as a physical consequence of cumulative socioeconomic disadvantage is antecedent to the known risk factors of poor pregnancy outcome.

The serious limitation faced in our analyses was the small number of women with short interpregnancy intervals. This is reflected in the fact that confidence intervals were consistently widest at the <= 6 months interval range. Of note, the similarity in shape of the frequency distribution of this cohort to that of national data lends support to the generalizability of the findings.

In conclusion, research into interpregnancy intervals as an explanation for disparities in pregnancy outcome is attractive given the potential for intervention and prevention. However, it is essential that the nature of the expected benefits be clarified. In order to do this, a better understanding of maternal depletion and the contributions of socioeconomic status to perinatal outcome are necessary. In particular, the mechanisms by which socioeconomic disadvantage exert a biologic effect remain unclear. It is unlikely that socioeconomic disadvantage causes adverse outcomes directly, however, it can limit access to medical care, restrict nutrition during and/or prior to pregnancy, produce stress and result in behaviors such as smoking and drug use that do exert direct biologic effects on pregnancy outcome.[34] While it is much easier through measures such as contraception and family planning to alter interpregnancy intervals, this should not be done at the expense of enhancing socioeconomic equality which from this study accounted for much of the racial disparity in SGA delivery. In particular, in our analysis, educational attainment was consistently associated with disparities in perinatal outcomes. The results suggest that efforts should be renewed in this area.

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VIII. APPENDIX A (Data for selected figures presented in the text)

Figure 1. data: Frequency distribution of interpregnancy intervals by race (SGA cohort)

	Interpregnancy interval (months)					
Race	**<=6**	**>6-12**	**>12-24**	**>24-36**	**>36-60**	**>60**
White (N)	4.8% (163)	13.5%(460)	30.5%(1036)	23.3% (792)	16.9% (574)	11.0%(375)
Black (N)	9.2% (53)	14.2%(82)	19.5%(113)	15.6% (90)	16.3% (94)	25.3% (146)

Figure 4. data: Percent term SGA births (no. of SGA births) by interpregnancy interval

	Interpregnancy interval (months)					
	<=6	**>6-12**	**>12-24**	**>24-36**	**>36-60**	**>60**
SGA (N)	7.4% (16)	5.7%(31)	4.8%(55)	2.4% (21)	3.7% (25)	3.8%(20)
AGA (N)	92.6% (200)	94.3%(511)	95.2%(1094)	97.6% (861)	96.3% (643)	96.2% (501)

Figure 5. data: Percent term SGA births (no. of SGA births) by interpregnancy interval and race

	Interpregnancy interval (months)					
	<=6	**>6-12**	**>12-24**	**>24-36**	**>36-60**	**>60**
White (N)	4.9% (8)	5.4%(25)	4.6% (48)	2.1% (17)	3.7% (2)	3.2%(12)
Black (N)	15.1% (8)	7.3% (6)	6.2% (7)	4.4% (4)	4.3% (4)	5.5% (8)

Figure 6. data: Frequency distribution of interpregnancy intervals by race (Preterm and LBW cohort)

	Interpregnancy interval (months)					
Race	**<=6**	**>6-12**	**>12-24**	**>24-36**	**>36-60**	**>60**
White (N)	4.9% (174)	13.7%(486)	30.3%(1076)	23.2% (820)	16.7% (594)	11.2%(399)
Black (N)	9.1% (57)	13.7%(86)	19.6%(123)	15.5% (97)	16.3% (102)	25.8% (162)

Figure 7. data: Percentage of women with preterm delivery (no. of preterm deliveries), by interpregnancy interval

	Interpregnancy interval (months)					
	<=6	>6-12	>12-24	>24-36	>36-60	>60
preterm (N)	6.5% (15)	5.2%(30)	4.2%(50)	3.8% (35)	4.0% (28)	7.1%(40)
term (N)	93.5% (216)	94.8%(542)	95.8%(1149)	96.2% (882)	96.0% (668)	92.9% (521)

Figure 8. data: Percentage of women with preterm delivery (no. of preterm deliveries), by interpregnancy interval and race

	Interpregnancy interval (months)					
Race	<=6	>6-12	>12-24	>24-36	>36-60	>60
White (N)	6.3% (11)	5.3%(26)	3.7% (40)	3.4% (28)	3.4% (20)	6%(24)
Black (N)	7.0% (4)	4.6% (4)	8.1% (10)	7.2% (7)	7.8% (8)	9.9% (16)

Figure 9. data: Percent LBW births (no. of LBW births), by interpregnancy interval

	Interpregnancy interval (months)					
	<=6	>6-12	>12-24	>24-36	>36-60	>60
LBW (N)	6.9% (16)	5.2%(36)	4.7%(57)	3.7% (34)	3.3% (23)	5.9%(33)
>=2500g(N)	93.1% (215)	93.7%(536)	95.2%(1142)	96.3% (883)	96.7% (673)	94.1% (528)

Figure 10. data: Percent LBW births (no. of LBW births) by interpregnancy interval and race

	Interpregnancy interval (months)					
Race	<=6	>6-12	>12-24	>24-36	>36-60	>60
White (N)	6.9% (12)	5.8%(28)	4.4% (47)	3.7% (30)	3.4% (20)	4.3%(17)
Black (N)	7.0% (4)	9.3% (8)	8.1% (10)	4.1% (4)	2.9% (3)	9.9% (16)