

# Timing of Incarceration During Pregnancy and Birth Outcomes: Exploring Racial Differences

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**Abstract** *Objectives* To examine whether there are racial differences in the relation between the timing of incarceration during pregnancy and birth outcomes among incarcerated pregnant women. *Methods* We examined the medical records associated with 360 infants born to pregnant inmates in Texas state prisons between January 1, 2002 and December 31, 2004. Weighted linear regression was used, within racial strata, to model gestational age at delivery, and infant birth weight, respectively, as functions of gestational age at maternal admission to prison. Models were adjusted for maternal age; gravidity; educational attainment; history of tobacco, substance, and alcohol use and the presence of any maternal chronic disease. *Results* Among Whites there was a 360.8 g lower mean birth weight for infants born to women incarcerated during weeks 14–20 relative to infants born to women incarcerated during weeks 1–13 ( $p < 0.10$ ). Among Blacks and Hispanics, incarceration after the first trimester was not associated with a significant decrease in infant birth weight relative to incarceration during the first trimester. White

women entering prison during the first trimester delivered infants at higher gestational ages than White women entering in the second trimester but the opposite was the case for Hispanics. *Conclusions* The association between the quantity of exposure to prison during pregnancy and birth outcomes appears to be different for Blacks, Whites, and Hispanic women. Future studies of the effect of incarceration on pregnancy outcomes should attempt to uncover potential racial differences in trends by obtaining racially stratified results or by assessing interaction with race.

**Keywords** Incarceration · Race · Birth outcomes

## Introduction

There has been growing interest in the birth outcomes of women who are incarcerated while pregnant due to the rapidly rising numbers of incarcerated women of child-bearing age. The number of women in state and federal prisons in the United States increased by 50% between 1995 and 2003 and now stands at approximately 102,000 [1]. Recent studies have even suggested that incarceration may have a paradoxically positive effect on birth outcomes [2–4]. However, neither the comparison between incarcerated pregnant women and non-incarcerated pregnant women, or the comparison of women with differing lengths of exposure to prison during pregnancy, have been examined by race to assess whether the relation between exposure to prison during pregnancy and pregnancy outcomes differs by race.

Kyei-Aboage et al. [4] compared the birth weights of the infants of pregnant prisoners in Massachusetts with those of high risk controls (pregnant women in a methadone

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clinic) and low risk controls. They found that, paradoxically, the pregnant incarcerated women delivered infants with significantly higher birth weights relative to pregnant women in a methadone clinic (who acted as high risk controls) and delivered infants whose birth weights were similar to those of infants born to low risk controls. This result echoed the findings a decade earlier of Egley et al. [5] and Martin et al. [2, 3] who both noted that incarcerated pregnant women in North Carolina delivered infants with birth weights that were statistically similar to those of infants born to low risk controls. Martin et al. [2, 3] went further in their studies and reported a positive dose-response relationship between the number of weeks of pregnancy spent incarcerated and infant birth weight among pregnant incarcerated women. These findings have stirred even further interest in the issue of pregnancy in prison because of the potential ramifications in terms of criminal justice policy decisions by lawmakers.

The sample sizes of prior studies of incarceration during pregnancy and birth outcomes may not have been large enough to permit meaningful stratification. Martin et al.'s study included 168 pregnant incarcerated women; Kyei-Aboagye's 2000 study included only 31 pregnant incarcerated women and two earlier studies in North Carolina by Cordero et al. [6] and Egley et al. [5] had cohorts of 106 and 69 pregnant incarcerated women, respectively.

The aim of this study was to examine a large enough cohort of pregnant incarcerated women to allow the assessment of differences across three major racial/ethnic groups: Hispanics, African Americans, and Whites. The Texas state prison system is one of the two largest state prison systems in the country. We focused on the association between the gestational age at admission to prison, and hence the amount of pregnancy exposed to prison, and two major birth outcomes—infant birth weight and gestational age at delivery. We hypothesized that this association, if existent, would be different across Whites, Blacks and Hispanics for at least one of our selected birth outcomes—consistent with the racial differences in pregnancy outcomes observed among women in the general population [7–18].

## Materials and Methods

### Study Design

This study employed a cross-sectional study design. The study period was from January 1, 2002 to December 31, 2004. The pregnant inmates in prison in the state of Texas served as our study population. A prison, in Texas, is a correctional facility for individuals sentenced to terms exceeding two years. To be included in the sample,

subjects had to have delivered while incarcerated and had to have delivered during the study period. All women in our study were already pregnant when they began their incarceration in the Texas prison system.

### Correctional Health Care in the Texas Dept of Criminal Justice

There are five female state prisons in Texas. Until 2004, women who were identified as being pregnant upon admission to prison or any time thereafter were sent to the Gatesville prison campus until the 32nd week of gestation at which point they would be transferred to a facility in Texas City, Texas a short drive away from the University of Texas Medical Branch-Galveston (UTMB) hospital where they would deliver. With the expansion of the facility in Texas City, beginning in early 2004, all pregnant women were transferred to this facility as soon after their incarceration or the point at which they realized they were pregnant (if they did not know they were pregnant at the time of admission to prison). A more thorough discussion of the design of the health care system in Texas state prisons can be found in a recently published article by Raimer and Stobo [19].

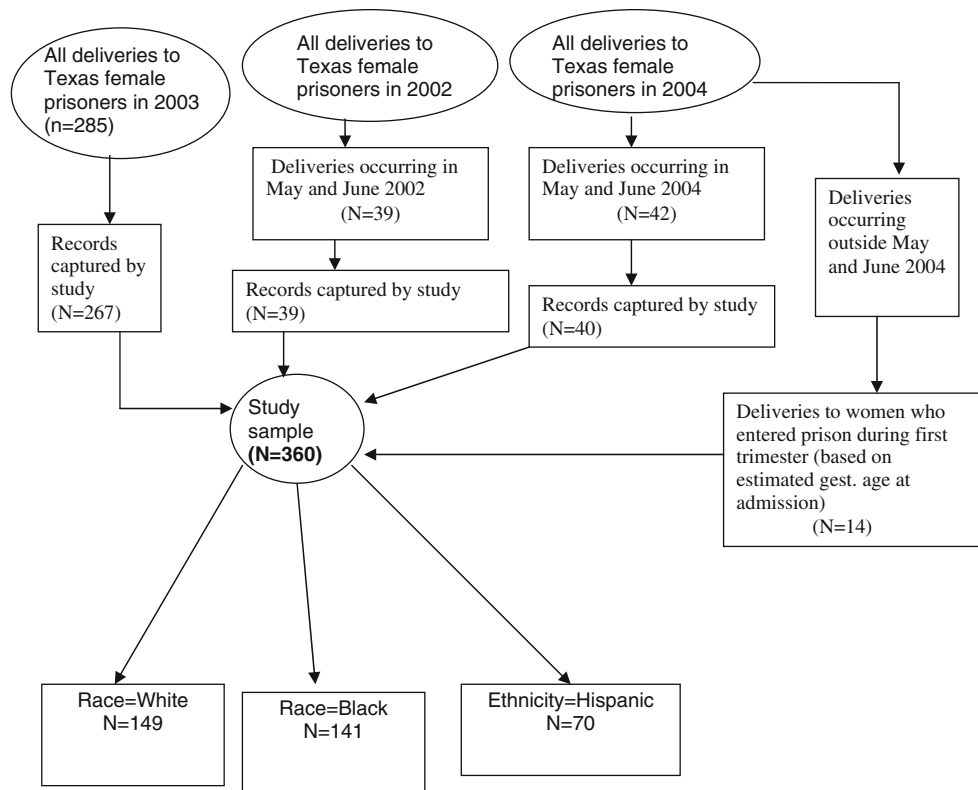
### Data Collection

Data were collected on each patient from multiple sources: the electronic medical record system maintained by the Correctional Managed Care division (UTMB-CMC) of UTMB (the division that contracts with the Texas Department of Criminal Justice (TDCJ)) to provide health care to the incarcerated in Texas); the paper-based delivery records maintained by the Obstetrics and Gynecology Department at UTMB; and the records of the Department of Child Protective Services that oversees the placement of babies born during their mother's incarceration—newborn infants are not allowed to stay with their mothers while they are incarcerated.

### Sampling Scheme

There were three sampling phases, as illustrated in Fig. 1. Phase one consisted of a complete census of all deliveries by female Texas state prison inmates occurring in 2003. Between January 1, 2003 and December 31, 2003, there were 285 deliveries occurring to 281 incarcerated women [four women had twins] and of these 285 deliveries our study captured 267. Since phase one was a census of all prison deliveries occurring in 2003, in our data analyses, each birth in phase one was assigned a sampling weight ( $1/\text{sampling probability}$ ) of 1. Phase one was the phase that was pre-specified in our initial study protocol. In phase two

**Fig. 1** Flow chart illustrating how the analysis sample was determined for the present study of the association between gestational age at admission and birth outcomes among White, Black and Hispanic pregnant prisoners delivering while incarcerated in Texas state prisons



of the sampling process the focus was on 2002 and 2004. Two months (May and June) were randomly chosen and the charts of all study-eligible women who delivered in those two months were examined. Collectively, 42 women delivered 42 infants in May and June of 2004 and a total of 39 women delivered 39 infants in May and June of 2002. Our study captured 40 out of the 42 deliveries in May and June of 2004 and all 39 deliveries occurring in May and June of 2002. In our analyses these infants were assigned a sampling weight (1/sampling probability) of six, with one caveat explained below, since they had a 1/6 probability of being sampled during each year.

The records of the Department of Child Protective Services, mentioned above, were used to compute the mean birth weight, by month of delivery, of all infants delivered of female inmates in Texas state prison for 2002 and 2004, the two years for which there was only a partial sample. The birthweight information in these records was obtained from the delivery records of the prisoners and was not by direct measurement by the staff of the Department of Child Protective Services. Using the Analysis of Variance (ANOVA) procedure, no statistically significant difference in mean birth weight was detected between any pair of months in 2002 and 2004 for pregnant inmates in the Texas state prison system.

In an effort to further increase the number of women in our sample who began their incarceration during the first trimester, a third sampling phase was initiated that

consisted of sampling all women delivering in 2004, outside of those delivering in May and June (captured during Phase 2), who had entered prison during the first trimester of gestation. The electronic medical record of each pregnant incarcerated woman in 2004 was examined and all women who delivered in 2004 and had an estimated gestational age at admission of 13 weeks or less were selected. This process was entirely dependent on either of two pieces of information being documented in the electronic medical record—the self reported gestational age estimate provided by women during their entry screening exam or a scan of the inmate’s prenatal care flow sheets which contain gestational age estimates at each prenatal care visit. The paper-based delivery records for these women were then used to obtain their outcome data, with the rest of their data coming from the electronic medical record system. This process resulted in 14 women being added to the sample. In the end, the study sample consisted of a total of 360 births—149 born to White mothers, 141 born to African American mothers, and 70 born to Hispanic mothers.

**Statistical Analyses**

Descriptive analyses were carried out using the SVY-MEAN and SVYTAB procedures in STATA (version 8, STATA Corp., TX). These procedures allow one to compute summary statistics for clustered data and or data with complex sampling designs. Our summary statistics are

therefore weighted by the sampling probabilities for each woman.

Our multivariate analyses consisted of two sets of racially stratified multiple linear regression models in which infant birth weight (in grams), and gestational age at delivery (in days), respectively, were modeled as functions of the gestational age at admission to prison while adjusting for age; gravidity; years of school completed; history of tobacco use; history of substance use; history of alcohol use; the presence of any chronic disease; and year of delivery.

To estimate gestational age at admission to prison we first abstracted the gestational age estimate at the first prison prenatal care visit as recorded on the antepartum care charts described above. We then subtracted the time interval between the first prenatal care visit and the date of admission to obtain an estimate of the gestational age at admission. In a parallel methodology, we worked backwards from the gestational age at delivery, obtained from the delivery records of each subject, to obtain a second estimate of the gestational age at admission. Not all women had two estimates however, because we were only able to obtain the maternal antepartum care flow sheets, containing data recorded at each prenatal care visit, for 147 of the 360 infants in our sample. We compared the two estimates of gestational age at admission, among those women for whom we were able to obtain two estimates, and found the correlation between the two estimates to meet criteria for statistical significance 0.88 ( $p = 0.001$ ).

Gestational age at admission to prison was divided into five mutually exclusive categories: incarceration during weeks 1–13; incarceration during weeks 14–20; incarceration during

weeks 21–27; incarceration during weeks 28–34; and incarceration during or past week 34. The reference category in the regression analysis was incarceration during weeks 1–13.

In another step, gestational age at admission to prison was modeled as a continuous linear spline transformed variable with cut points at week 13; week 20; week 27; and week 34—so that the analyses would be comparable to the analyses where gestational age at admission was modeled categorically. Spline regression has the advantage of using all data points to estimate the shape of the association between an exposure and a disease and of being able to fit complex distributions as well as linear associations. Also, unlike traditional linear regression, data points at one location do not influence the fit at other locations [20–22].

## Results

Table 1 illustrates the general characteristics of our study sample. There were 149 infants born to White women, 141 infants born to Black women, and 70 infants born to Hispanic women. Whites were slightly more likely than Blacks and Hispanics to enter prison during the first trimester while Blacks were slightly more likely than Whites or Hispanics to enter prison after week 34 of gestation. Hispanics were somewhat more likely to enter prison at less than 20 years of age relative to Whites and Blacks. White women were the most likely to have completed high school prior to the initiation of their incarceration and Black women were the least likely to be primigravid at admission. Whites were the most likely to have a chronic disease present at admission

**Table 1** Selected characteristics, by race, of pregnant females delivering while incarcerated in Texas state prisons between January 1, 2002 and December 31, 2004<sup>a</sup>

	Whites ( <i>N</i> = 149) <i>N</i> (%)	Blacks ( <i>N</i> = 141) <i>N</i> (%)	Hispanics ( <i>N</i> = 70) <i>N</i> (%)
Entered prison during weeks			
1–13	25 (12.5)	19 (10.8)	9 (8.4)
14–20	26 (14.7)	41 (33.3)	12 (25.2)
21–27	31 (22.9)	27 (21.2)	13 (21.5)
28–34	39 (32.3)	20 (24.8)	22 (30.8)
Past week 34	13 (17.6)	12 (9.9)	10 (14.0)
Primigravid at admission	21 (14.1)	11 (7.4)	12 (14.1)
Age at admission			
<20	7 (5.6)	8 (4.8)	3 (7.6)
High school completed	69 (45.2)	55 (40.2)	21 (34.7)
Chronic disease present at admission	59 (52.1)	41 (50.0)	16 (24.7)
History of substance use	79 (58.2)	47 (33.4)	29 (38.2)
Pre-incarceration tobacco use	77 (54.8)	50 (39.6)	23 (32.3)
Pre-incarceration alcohol use	49 (39.6)	29 (21.7)	14 (19.0)
Pre-incarceration STD history	27 (25.0)	39 (30.5)	20 (20.4)

<sup>a</sup> All frequencies are actual frequencies while all percentages are weighted

**Table 2** Racially stratified, unadjusted weighted mean birth weight and gestational age at delivery by gestational age at maternal admission to prison of 360 infants born to pregnant inmates in Texas state prisons between January 1 2002 and December 31 2004

	Gestational age at maternal admission to prison (in weeks)				
	1–13 (first trimester)	14–20	21–27	28–34	Past week 34
<b>Whites</b>					
	<i>N</i> = 25	<i>N</i> = 26	<i>N</i> = 35	<i>N</i> = 41	<i>N</i> = 28
Infant birth weight/g (mean [95% CI])	3570.6 3331.1–3810.1	3308.5 2470.5–4146.4	3586.4 2758.3–4414.5	3252.7 3102.4–3402.9	3352 2779.7–3925.9
Gestational age at delivery/days (mean [95%CI])	278.4 263.9–292.9	268.6 232.7–304.5	269.1 257.2–281.0	270.5 246.0–295.1	279.3 274.8–283.8
<b>Blacks</b>					
	<i>N</i> = 18	<i>N</i> = 40	<i>N</i> = 27	<i>N</i> = 19	<i>N</i> = 37
Infant birth weight/g (mean [95% CI])	3121.9 2673.7–3570.2	3251.6 2589.2–3914.1	3071.2 1490.7–4651.8	3264.1 3060.9–3467.2	2934.7 2297.5–3572.0
Gestational age at delivery/days (mean [95%CI])	268.7 259.0–278.4	262.5 247.6–277.4	263.9 236.9–290.9	278.1 266.9–289.3	276.6 264.1–289.0
<b>Hispanics</b>					
	<i>N</i> = 9	<i>N</i> = 12	<i>N</i> = 12	<i>N</i> = 25	<i>N</i> = 13
Infant birth weight/g (mean [95% CI])	3419.0 2844.3–3993.7	3040.5 2001.8–4079.2	3421.4 2442.3–4400.5	3013.1 1521.1–4504.9	3308.5 2768.9–3848.1
Gestational age at delivery/days (mean [95%CI])	264.7 259.9–269.4	255.4 215.3–295.5	271.7 261.6–281.9	265.3 234.8–295.8	276 270.9–281.1

and the most likely to report a history of substance use, tobacco use and alcohol use.

Table 2 shows the unadjusted mean birth weights and gestational ages at delivery, by gestational age at admission to prison, within racial strata.

Multivariate Analyses

*Birth Weight (Table 3)*

Among Whites, there was a 360.8 g lower mean birth weight for infants born to women incarcerated during weeks 14 through 20 of gestation relative to infants born to women incarcerated during weeks 1–13 (*p* = 0.06). There was also a decrease of 319.3 g in the mean birth weight of infants born to White women incarcerated during weeks 28–34 relative to infants born to those incarcerated during weeks 1–13 (*p* = 0.02). However, among Blacks and Hispanics, incarceration after the first trimester was not associated with a statistically significant decrease in infant birth weight relative to incarceration during the first trimester.

The race-specific results obtained from modeling gestational age at admission as a continuous, linear spline transformed variable (shown in Fig. 2) similarly showed

that the relation between gestational age at admission to prison and infant birth weight appeared to be different across White, Black and Hispanic women in our study.

*Gestational Age at Delivery (Table 4)*

We found that among White and Black women but not among Hispanic women, incarceration during weeks 14–20 was associated with a decrease in mean gestational age at delivery relative to incarceration during weeks 1–13.

We also found that among White women, relative to incarceration during the first trimester, incarceration during weeks 21–27 of gestation was associated with a decrease in mean gestational delivery. This was in contrast to Hispanic women among whom incarceration during weeks 21–27 was associated with an increase in gestational age at delivery relative to incarceration during the first trimester.

When gestational age at admission was modeled as a continuous variable (subjected to linear spline transformation) the results, shown in Fig. 3, echoed those obtained when it was modeled as a categorical variable. The association between gestational age at admission and gestational age at delivery appeared to be different across White, Black and Hispanic women in our study.

**Table 3** Infant birth weight versus timing of incarceration during pregnancy, by race, among female inmates in Texas state prisons who delivered between January 1, 2002 and December 31, 2004<sup>a</sup>

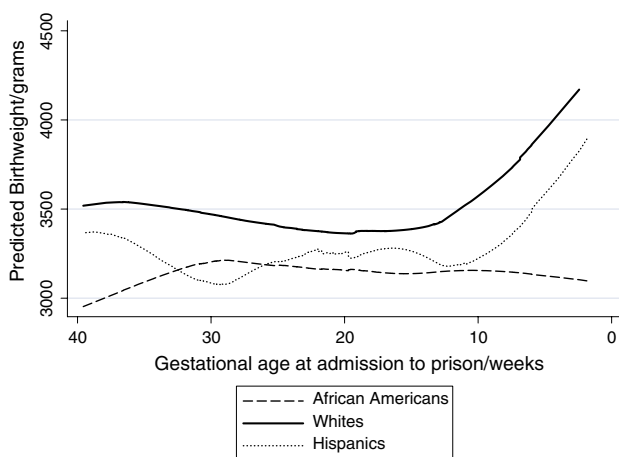
	Coefficients from regression modeling (g)					
	All races	Whites (Model <i>N</i> = 138) $\beta$ (SE) A	Blacks (Model <i>N</i> = 123)		Hispanics (Model <i>N</i> = 61)	
			$\beta$ (SE) B	<i>p</i> -value A–B <sup>b</sup>	$\beta$ (SE) C	<i>p</i> -value A–C <sup>c</sup>
Incarcerated during weeks 1–13 (reference)						
Incarcerated during weeks 14–20	–119.1 (117.6)	–360.8 (188.3)**	63.2 (167.8)	0.11	–49.6 (329.9)	0.93
Incarcerated during weeks 21–27	–40.2 (154.3)	–78.3 (190.7)	–16.4 (204.3)	0.84	185.9 (312.5)	0.91
Incarcerated during weeks 28–34	–225.1 (129.0)	–319.3 (127.2)*	–8.7 (198.6)	0.12	–457.8 (317.9)	0.86
Incarcerated past week 34	–104.1 (129.0)	–141.2 (322.7)	84.7 (222.4)	0.47	–205.3 (403.7)	0.87

<sup>a</sup> Race specific results obtained from models adjusted for: maternal age; years of school completed; gravidity; history of substance use; history of tobacco use; history of alcohol use; the presence of any chronic disease at admission to prison; and year of delivery

<sup>b</sup> The *p*-values in this column represent the statistical significance level associated with the difference between the coefficients among White women and the coefficients among Black women representing the association between adjusted mean infant birth weight and incarceration during weeks 14–20, 21–27, 28–34 and past week 34, respectively, relative to incarceration during the first trimester

<sup>c</sup> The *p*-values in this column represent the statistical significance level associated with the difference between the coefficients among White women and the coefficients among Hispanic women representing the association between adjusted mean infant birth weight and incarceration during weeks 14–20, 21–27, 28–34 and past week 34, respectively, relative to incarceration during the first trimester

\*  $p < 0.05$ ; \*\*  $p < 0.10$



**Fig. 2** Infant birth weight versus timing of incarceration during pregnancy among White and African American female inmates in Texas state prisons who delivered between January 1, 2002 and December 31, 2004. Plots were derived from weighted linear regression models which adjusted for: maternal age, years of school completed, gravidity, history of substance abuse, history of tobacco use, history of alcohol use, the presence of chronic disease at admission to prison, and year of delivery (2002 vs. 2003; 2004 vs. 2003)

#### Testing for Racial Differences (Tables 3 and 4)

To test for racial differences in the association between gestational age at admission to prison and each pregnancy outcome we constructed linear regression models with terms representing the interaction between Black race and each category of gestational age at admission and between Hispanic ethnicity and each category of gestational age at

admission to prison. For each of the two outcomes examined, infant birth weight and gestational age at delivery, at least one interaction term was statistically significant at the 10% level.

#### Discussion

In this study racial differences were found in the association between gestational age at admission to prison and each of the two birth outcomes examined (infant birth weight and gestational age at delivery). For infant birth weight we found that among Whites, women who came into prison after the first trimester had infants with lower adjusted mean birth weights than those of infants born to women who entered prison in the first trimester; the difference reached significance only for women entering prison during weeks 14–20 and weeks 28–34 of gestation. In contrast, there was little evidence for a trend among Blacks or Hispanics. Studies focusing on pregnancy in prison have over the past 15 years consistently reported evidence suggestive of a paradoxical positive association between incarceration during pregnancy and infant birth weight [2–6]. However, our findings suggest that this particular infant birth weight paradox may actually be limited to White women and may not be present among Black or Hispanic women.

The effect of gestational age at admission to prison on gestational age at delivery was similar for Whites and Blacks. The effect was qualitatively different, however, for Hispanic women. Among both Blacks and Whites,

**Table 4** Gestational age at delivery in days versus timing of incarceration during pregnancy, by race, among female inmates in Texas state prisons who delivered between January 1, 2002 and December 31, 2004<sup>a</sup>

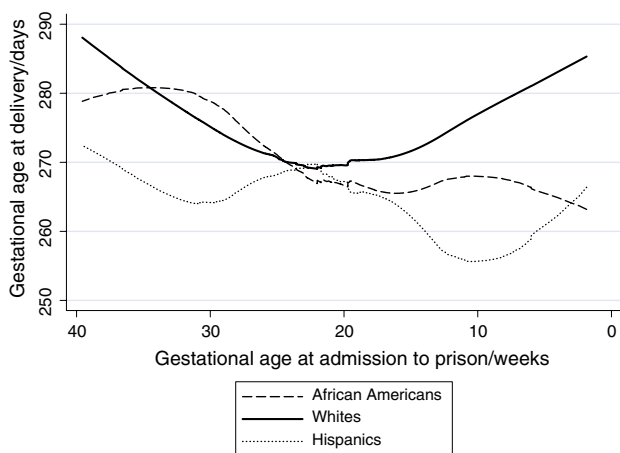
	Coefficients from regression modeling (days)					
	All races	Whites (Model <i>N</i> = 132) $\beta$ (SE) A	Blacks (Model <i>N</i> = 112)		Hispanics (Model <i>N</i> = 60)	
			$\beta$ (SE) B	<i>p</i> -value [A–B] <sup>b</sup>	$\beta$ (SE) C	<i>p</i> -value [A–C] <sup>c</sup>
Incarcerated during weeks 1–13 (reference)						
Incarcerated during weeks 14–20	-9.41 (3.8)*	-11.7 (6.5)**	-5.6 (4.4)	0.52	7.4 (7.6)	0.30
Incarcerated during weeks 21–27	-6.42 (3.4)	-9.6 (3.1)*	-5.1 (5.3)	0.79	19.6 (6.8)*	0.001
Incarcerated during weeks 28–34	-0.11 (3.1)	-4.5 (3.8)	11.2 (5.2)*	0.01	4.1 (6.7)	0.26
Incarcerated past week 34	3.88 (2.9)	2.8 (5.4)	11.4 (4.6)*	0.36	10.5 (7.7)	0.44

<sup>a</sup> Race specific results obtained from models adjusted for: maternal age; years of school completed; gravidity; history of substance use; history of tobacco use; history of alcohol use; the presence of any chronic disease at admission to prison; and year of delivery

<sup>b</sup> The *p*-values in this column represent the statistical significance level associated with the difference between the coefficients among White women and the coefficients among Black women representing the association between adjusted mean infant birth weight and incarceration during weeks 14–20, 21–27, 28–34 and past week 34, respectively, relative to incarceration during the first trimester

<sup>c</sup> The *p*-values in this column represent the statistical significance level associated with the difference between the coefficients among White women and the coefficients among Hispanic women representing the association between adjusted mean infant birth weight and incarceration during weeks 14–20, 21–27, 28–34 and past week 34, respectively, relative to incarceration during the first trimester

\* *p* < 0.05; \*\* *p* < 0.10



**Fig. 3** Gestational age at delivery versus timing of incarceration during pregnancy, by race, among female inmates in Texas State prisons who delivered between January 1, 2002 and December 31, 2004. Plots were derived from weighted linear regression models which adjusted for: maternal age, years of school completed, gravidity, history of substance abuse, history of tobacco use, history of alcohol use, the presence of chronic disease at admission to prison, and year of delivery (2002 vs. 2003; 2004 vs. 2003)

incarceration during weeks 14–20, and during weeks 21–27, respectively were associated with decreases in gestational age at delivery relative to incarceration during the first trimester—although these differences only achieved statistical significance among Whites. For Hispanics however, women entering prison during the second trimester, in particular those who entered during weeks 21–27, delivered infants at higher gestational ages relative to women entering prison in the first trimester.

The findings regarding infant birth weight, prompt the question, why would differing amounts of exposure during pregnancy in a relatively controlled environment, such as prison have disparate effects on infant birth weight among African Americans, Hispanics and Whites? The answer may very well lie in the characteristics of the three groups shown in Table 1. Whites were more likely than Blacks or Hispanics to report a history of substance use, tobacco use and alcohol use and had similar percentages as Black women of having a chronic disease present at admission. Hispanics, on the other hand, were the least likely to have a chronic disease present at admission, to report a history of tobacco use and alcohol use and to report having contracted an STD in the past. From an obstetric standpoint, Whites in the sample had the more severe clinical profile at admission to prison, and may have benefited more than Blacks or Hispanics from spending greater proportions of their pregnancy exposed to an environment where they would have had regular access to obstetric care. From a policy standpoint, the findings may acknowledge the importance of reducing high risk behaviors. In this case, the highest risk women may have received the greatest benefit of the longest exposure to the more controlled environment. Alternatively, the findings may suggest differential attention to the women by race, either because of differences in risk profile, or for other reasons related to the complexities of the prison environment. While we cannot assess this in our study, the finding does suggest the need to carefully review staff, policies and treatment of pregnant women in prisons.

When the outcome was birthweight the association with gestational age at admission to prison was different for

Whites relative to Blacks. On the other hand when the outcome was gestational age at delivery, the association with gestational age at admission to prison was not different for Whites relative to Blacks. Negative health behaviors tend to be more strongly related to birth weight than to gestational age at delivery [23] and thus greater reduction in negative health behaviors may be responsible for our birthweight findings. If our gestational age at delivery results were identical to our birth weight results then there would be a very plausible biological explanation for our results: for White but not for Black women, incarceration after the first trimester was associated with lower gestational ages at delivery and hence among Whites but not Blacks incarceration after the first trimester was associated with lower birthweight. Our results concerning Hispanics must be interpreted with caution, however, as the number of Hispanics in our sample was relatively small compared with the size of the sample for Blacks and Whites; only 9 Hispanic women entered the prison in the first trimester. Consequently, the association between gestational age at admission to prison and birth outcomes among Hispanics in our study may have been influenced by the comparatively smaller size of this subgroup.

There are several other limitations pertinent to this study. First, we were not able to prospectively control for the occurrence of C-sections. Convenience C-sections represent an artificial end to pregnancy and therefore gestational age at delivery will have an artifactual component. Secondly, we did not have the records for any care received by our cohort of women in the part of their pregnancy before entering the criminal justice system. We also did not have complete and reliable data on past pregnancy outcomes. The prior occurrence of an adverse pregnancy outcome is known to be among the strongest predictors of future birth outcomes [24]—strong enough to outweigh any possible beneficial effect of long exposure to prison during pregnancy. Prior studies have also showed that Black women who have had a preterm infant are at higher risk for subsequent preterm delivery than White women with a similar history [25]. This could at least partially explain our observation that White but not Black inmates delivered infants at both higher birth weights and higher gestational ages relative to their counterparts who entered prison after the first trimester. We did adjust for chronic medical conditions and past substance use but it is possible that our model may still have not adequately captured these factors. These variables were based on self-reported data and there may have been differential under or over reporting of past substance use in particular across the three racial groups. A study by Harris et al. [26] among adolescents found that Blacks reported inconsistently on less than half the number of substances as compared with Whites. In contrast, a study by Fendrich and Johnson [27] among adults found that the

concordance between self-reports of recent cocaine and marijuana use and drug test results was lower for Blacks than for Whites and Hispanics. Both studies are suggestive of the possibility that the sensitivity of self reports of substance use might vary by race and if this was the case in our study then that could have an impact on results. We were not able to compare incarcerated pregnant women as a whole to non-incarcerated pregnant women—our study focused exclusively on the effect of differing amounts of exposure to prison during pregnancy among women incarcerated during pregnancy. Finally, we were not able to control for stress or violence experienced both before entering and in prison, or to measure the use of tobacco, drugs or alcohol while the women were in prison. Stress and violence experienced before incarceration may be factors that partially account for the lack of findings for Black and Hispanic women.

Despite the above limitations, the results suggest that by placement in a potentially more protective environment early in pregnancy, the white, high risk women in the study sample showed better outcomes than those coming into the environment later in pregnancy. A free-world parallel to the prison system may be the military in that access to health care is not an issue in either the military or prison and the military and the prison settings are both very controlled environments. As several studies have shown, however, even in the military, racial disparities persist in birth outcomes [14, 28–30]. The problem however is that the issue at hand is not the difference in birth outcomes between Whites, Blacks and Hispanics but rather the difference in the association between the quantity of an exposure (prison during pregnancy) and birth outcomes across the three racial/ethnic groups.

One free-world study conducted by Rawlings et al. [28, 30] consisted of an analysis of births to military women in which the central question was not whether Black and White women had different birth outcomes but rather whether the association between the interval between consecutive pregnancies and birth outcomes was different among Blacks than it was among Whites. Among Black women, pregnancy intervals shorter than nine months were associated with higher rates of preterm delivery and low-birth weight in neonates, but among Whites, only inter-pregnancy intervals of less than three months were associated with worse birth outcomes. There is a precedent therefore for associations between putative risk factors and select birth outcomes to be different across racial/ethnic groups—even within a controlled environment characterized by universal health care.

Considering prisons in a social context may be important in shedding some light on the meaning of the findings, from the standpoint of understanding why the influence of the prison environment on birth outcomes is different across racial/ethnic groups. The first implication would be



to understand its potentially protective aspects for the seemingly highest risk group in the sample, the White women. This finding is consistent with studies of low income White and Black women that show greater differences in birth weight between the two groups when adjustment is made for high risk health behaviors [31]. The second implication is in exploring whether or not there may be racial differences in the experiences of the pregnant women while incarcerated. This implication is only suggested by the results but prompts the need to look more closely at the treatment of pregnant women in prisons.

In conclusion, there appear to be racial differences in the association between gestational age at admission to prison and birth outcomes. These results, if replicated, have potentially significant implications for criminal justice policy decisions regarding pregnant women in the criminal justice system.

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## References

- Harrison, P., & Beck, A. (2005). *Bureau of justice statistics bulletin: Prison and jail inmates at midyear 2004*. Washington DC: U.S. Department of Justice.
- Martin, S. L., Rieger, R. H., Kupper, L. L., et al. (1997). The effect of incarceration during pregnancy on birth outcomes. *Public Health Reports*, 112(4), 340–346.
- Martin, S. L., Kim, H., Kupper, L. L., et al. (1997). Is incarceration during pregnancy associated with infant birthweight? *American Journal of Public Health*, 87(9), 1526–1531.
- Kyei-Aboagye, K., Vragovic, O., & Chong, D. (2000). Birth outcome in incarcerated, high-risk pregnant women. *The Journal of Reproductive Medicine*, 45(3), 190–194.
- Egley, C. C., Miller, D. E., Granados, J. L., et al. (1992). Outcome of pregnancy during imprisonment. *The Journal of Reproductive Medicine*, 37(2), 131–134.
- Cordero, L., Hines, S., Shibley, K. A., et al. (1991). Duration of incarceration and perinatal outcome. *Obstetrics and Gynecology*, 78(4), 641–645.
- Alexander, G. R., & Cornely, D. A. (1987). Racial disparities in pregnancy outcomes: The role of prenatal care utilization and maternal risk status. *American Journal of Preventive Medicine*, 3(5), 254–261.
- Arias, E., MacDorman, M. F., Strobino, D. M., et al. (2003). Annual summary of vital statistics—2002. *Pediatrics*, 112(6 Pt 1), 1215–1230. doi:10.1542/peds.112.6.1215.
- Guyer, B., Hoyert, D. L., Martin, J. A., et al. (1999). Annual summary of vital statistics—1998. *Pediatrics*, 104(6), 1229–1246. doi:10.1542/peds.104.6.1229.
- Hessol, N. A., Fuentes-Afflick, E., & Bacchetti, P. (1998). Risk of low birth weight infants among black and white parents. *Obstetrics and Gynecology*, 92(5), 814–822. doi:10.1016/S0029-7844(98)00310-X.
- Hoyert, D. L., Freedman, M. A., Strobino, D. M., et al. (2001). Annual summary of vital statistics: 2000. *Pediatrics*, 108(6), 1241–1255. doi:10.1542/peds.108.6.1241.
- James, S. A. (1993). Racial and ethnic differences in infant mortality and low birth weight. A psychosocial critique. *Annals of Epidemiology*, 3(2), 130–136.
- MacDorman, M. F., Minino, A. M., Strobino, D. M., et al. (2002). Annual summary of vital statistics—2001. *Pediatrics*, 110(6), 1037–1052. doi:10.1542/peds.110.6.1037.
- Barfield, W. D., Wise, P. H., Rust, F. P., et al. (1996). Racial disparities in outcomes of military and civilian births in California. *Archives of Pediatrics & Adolescent Medicine*, 150(10), 1062–1067.
- Hogan, V. K., Njoroge, T., Durant, T. M., et al. (2001). Eliminating disparities in perinatal outcomes—lessons learned. *Maternal and Child Health Journal*, 5(2), 135–140. doi:10.1023/A:1011357317528.
- Richardson, G. A., Day, N. L., & McGauhey, P. J. (1993). The impact of prenatal marijuana and cocaine use on the infant and child. *Clinical Obstetrics and Gynecology*, 36(2), 302–318. doi:10.1097/00003081-199306000-00010.
- Lu, M. C., & Chen, B. (2004). Racial and ethnic disparities in preterm birth: The role of stressful life events. *American Journal of Obstetrics and Gynecology*, 191(3), 691–699. doi:10.1016/j.ajog.2004.04.018.
- Lu, M. C., & Halfon, N. (2003). Racial and ethnic disparities in birth outcomes: A life-course perspective. *Maternal and Child Health Journal*, 7(1), 13–30. doi:10.1023/A:1022537516969.
- Raimer, B. G., Patterson, P., & Boulinghouse, O. (2005). *Correctional health care in the Texas department of criminal justice*. Galveston, TX: University of Texas Medical Branch.
- Greenland, S. (1995). Dose-response and trend analysis in epidemiology: Alternatives to categorical analysis. *Epidemiology (Cambridge, Mass.)*, 6(4), 356–365.
- Greenland, S. (1995). Avoiding power loss associated with categorization and ordinal scores in dose-response and trend analysis. *Epidemiology (Cambridge, Mass.)*, 6(4), 450–454.
- Greenland, S. (1995). Problems in the average-risk interpretation of categorical dose-response analyses. *Epidemiology (Cambridge, Mass.)*, 6(5), 563–565. doi:10.1097/00001648-199509000-00020.
- Faden, V. B., Hanna, E., & Graubard, B. I. (1997). The effect of positive and negative health behavior during gestation on pregnancy outcome. *Journal of Substance Abuse*, 9, 63–76. doi:10.1016/S0899-3289(97)90006-7
- Adams, M. M., Elam-Evans, L. D., Wilson, H. G., et al. (2000). Rates of and factors associated with recurrence of preterm delivery. *Journal of the American Medical Association*, 283(12), 1591–1596. doi:10.1001/jama.283.12.1591.
- Kistka, Z. A., Palomar, L., Lee, K. A., et al. (2007). Racial disparity in the frequency of recurrence of preterm birth. *American Journal of Obstetrics and Gynecology*, 196(2), 131.e1–131.e6.
- Harris, K. M., Griffin, B. A., McCaffrey, D. F., et al. (2007). Inconsistencies in self-reported drug use by adolescents in substance abuse treatment: Implications for outcome and performance measurements. *Journal of Substance Abuse Treatment*.
- Fendrich, M., & Johnson, T. P. (2005). Race/ethnicity differences in the validity of self-reported drug use: Results from a household survey. *Journal of Urban Health*, 82(2 Suppl 3), iii67–iii81. doi:10.1093/urban/jti065.
- Rawlings, J. S., Rawlings, V. B., & Read, J. A. (1995). Prevalence of low birth weight and preterm delivery in relation to the interval between pregnancies among white and black women. *New England Journal of Medicine*, 332(2), 69–74. doi:10.1056/NEJM199501123320201.
- Yoder, B. A., & Young, M. K. (1997). Neonatal outcomes of teenage pregnancy in a military population. *Obstetrics and*

- Gynecology*, 90(4 Pt 1), 500–506. doi:[10.1016/S0029-7844\(97\)00357-8](https://doi.org/10.1016/S0029-7844(97)00357-8).
30. Rawlings, J. S., & Weir, M. R. (1992). Race- and rank-specific infant mortality in a US military population. *American Journal of Diseases of Children (1960)*, 146(3), 313–316.
31. Cliver, S. P., Goldenberg, R. L., Cutter, G. R., et al. (1992). The relationships among psychosocial profile, maternal size, and smoking in predicting fetal growth retardation. *Obstetrics and Gynecology*, 80(2), 262–267.