Birth-to-pregnancy intervals and adverse perinatal outcomes among African-born black women in Washington State.

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Abstract

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Background: Short birth-to-pregnancy (BTP) intervals are associated with adverse perinatal outcomes. The number of African-born blacks currently living in the U.S. exceeds 1.6 million. However, little is known about BTP intervals and the risk factors and outcomes related to short BTP intervals among African-born women living in the U.S.
Objectives: The objectives of this study were to: (1) Investigate risk of short BTP and BTP-related risk factors and perinatal outcomes among African-born black women in Washington State, and (2) evaluate whether short BTP intervals modify the relationship between maternal birth country and race and perinatal outcomes among African-born black, U.S.-born white, and U.S.-born black women.
Methods: This was a retrospective cohort study using data from linked birth certificate and hospital discharge records for 18,984 consecutive, singleton birth pairs to African-born black (n=3,312), U.S.-born white (n=7,839) and U.S.-born black women (n=7,833) in Washington State from 1992-2013. Short BTP interval was defined as <6 months between date of delivery of preceding live birth and conception date of a subsequent pregnancy. Logistic regression models were used to determine adjusted odds ratios (aOR) and 95% confidence intervals (CI). Effect modification was evaluated using stratified analyses.

Results: Women with short BTP intervals comprised 10.0% of African-born women, 4.3% of U.S.-born white women, and 6.8% of U.S.-born black women. African-born women had 3-fold and 1.5-fold higher risk of short BTP intervals compared with U.S.-born white women (aOR 3.44; 95%CI: 2.53-4.68) and U.S.-born black women (aOR 1.49; 95%CI: 1.28-1.74). Among African-born women, those who were born in Eastern Africa (aOR 3.17; 95%CI: 1.92, 5.24), nulliparous (aOR 1.37; 95%CI: 1.01-1.86), had ≤ high school education (aOR 1.92; 95%CI: 1.41-2.61), and previous vaginal delivery (aOR 1.78; 95%CI: 1.29-2.44) were at higher risk for short BTP intervals. Among women with normal BTP interval, African-born black women had almost two-fold higher risk of having low birthweight (aOR 1.89; 95%CI: 1.10-3.23) infants compared with U.S.-born white women. This association was not observed among women with short or intermediate BTP intervals.

Conclusions: African-born black women are at higher risk for short BTP intervals than U.S.-born white and black women. We identified several risk factors that may contribute to short BTP among African-born black women. Given the link between short BTP intervals and adverse perinatal outcomes, additional efforts are needed to better understand factors affecting pregnancy spacing among African-born women.

Introduction:

Short birth to pregnancy intervals (BTP intervals) have been associated with both adverse neonatal outcomes, such as low birth weight (LBW), preterm birth (PTB), small-for-gestational age (SGA) infants and neonatal mortality, as well as adverse maternal outcomes, such as utero-placental bleeding disorders (e.g. placenta previa and placental abruption).[1-4] U.S. black women and other minority groups have shorter BTP intervals and increased risk of adverse perinatal outcomes compared with U.S. white women. [5-7] Studies suggest that certain immigrant populations, including African and Asian subgroups, are at higher risk of adverse neonatal and maternal pregnancy outcomes compared with women born in the industrialized countries to which immigrants move.[8-10] However, little is known about how BTP intervals and risk of related perinatal complications differ among immigrant populations in the U.S. As the population of immigrants in the U.S. is growing, it is important to study modifiable risk factors, such as BTP interval, that contribute to adverse perinatal outcomes. To date, no study has investigated BTP intervals and associated risk factors among various U.S. immigrants or whether BTP intervals contribute to adverse perinatal outcomes among foreign-born women in the U.S.

This study focuses on African-born immigrants because they represent a growing immigrant population with 1.6 million African-born blacks currently living in the U.S. African-born blacks make up about 4% of the foreign-born population, which represents a doubling of this immigrant group from a decade ago.[11] In Washington State, 5.9% of the foreign-born population was from Africa in 2010.[12] In comparison to women born in industrialized countries, African-born women experience disparate pregnancy outcomes after immigrating to these countries.[13,14] A study from the Swedish birth registry found that sub-Saharan African immigrant mothers had 1.21-fold (95% CI 1.05, 1.38) higher odds of LBW compared with native Swedish mothers.[15] In addition, several studies have shown that refugee women have increased risk for adverse obstetric and neonatal outcomes such as SGA infants[16], stillbirth[13,14], and emergency cesarean sections[14,16] compared with U.S.-born women and women born in other European countries.

African immigrants, have unique social, cultural, and sometimes religious views that influence family planning practices and reproductive health.[17-19] The objective of our study was to

(1) examine the differences in BTP intervals among African-born black women compared with U.S.-born white and U.S.-born black women, (2) identify the risk factors for short BTP interval among African-born black women, and (3) examine the role of BTP interval in associations of maternal birth country and race with adverse perinatal outcomes among women who gave birth in Washington State.

Methods:

We performed a population based retrospective cohort study of births to women residents of Washington State between 1992 and 2013. Data were obtained from linked birth certificate and hospital discharge records using the Birth Events Records Database (BERD) and Comprehensive Hospital Abstract Reporting System (CHARS) in Washington State. The total number of African-born women delivering two, consecutive, singleton infants during the study period was 3,947. Our study population (a total of 19,713 birth pairs) included consecutive, live birth pairs to U.S.-born white women (N=7,872 birth pairs) and U.S.-born black women (N=7,894 birth pairs) matched by calendar year two to one with African-born black women (N=3,947 birth pairs) delivering singleton infants. We excluded records that had missing or negative BTP intervals (n=105) and records from non-black African-born women (n=624). Thus, analyses were limited to 18,984 consecutive, singleton birth pairs to African-born black (n=3,312), U.S.-born white (n=7,839) and U.S.-born black women (n=7,833). As the data for this study was de-identified, this study was exempt from review by the institutional review board at the University of Washington, Seattle, WA.

The exposure of interest was maternal country of birth and race with the exposed cohort being African-born black women while the comparison groups were U.S.-born white and U.S. born black women. In addition, we subdivided African-born black women by African-region of birth according to the United Nations designation of regions of Africa.[20] We grouped women born in Central, Western, Northern, and Southern African together because of small numbers (e.g. n<5) of women with short or intermediate BTP intervals among each region.

The primary outcome of interest was BTP interval, defined as the time period between the most recent, preceding live birth and conception of the index birth.[21,22] BTP interval was calculated from birth certificate records by subtracting the gestational length of the second pregnancy from the time period between two consecutive deliveries. BTP interval was evaluated as a continuous and categorical outcome, with categories defined as < 6 months (short), 6 to <18 months (intermediate), ≥ 18 to <60 months (normal), and ≥ 60 months (long).[21,23,24] The neonatal outcomes we assessed included PTB, defined as birth prior to 37 weeks completed gestation; LBW, defined as birth weight of infant <2500 grams and evaluated as a continuous and dichotomous variable; SGA, defined as birth weight of infant < 10th percentile for gestation age. The maternal outcomes we assessed included anemia, as reported in Washington State birth certificates and by ICD-9 diagnosis codes from hospital discharge records, and pre-pregnancy body mass index (BMI), as recorded on birth certificates starting in 2003.

Maternal characteristics included as covariates were maternal age (≤19, 20-34, ≥35 years), educational status (≤12 years, > 12 years), parity (nulliparous, multiparous), marital status (yes/no), neonatal death (death within the first 28 days of life: yes/no), delivery type (vaginal or cesarean delivery), pre-pregnancy BMI (kg/m^2) (continuous variable), tobacco smoking during pregnancy (yes/no), and prenatal care adequacy, which was calculated as the Kotelchuk index/Adequacy of Prenatal Care Use Index (APCU) and categorized as inadequate, intermediate, adequate, adequate plus.[25]

The following values were identified as implausible and recoded as missing: gestational age >44 weeks, birth weight >6000 grams, birth weight <500 g for gestational age ≥ 32 weeks and birth weight <1000 g for gestational age ≥ 37 weeks.[26] Records with missing data were excluded from relevant analyses.

There were minimal missing data, ≤ 1% for maternal characteristics except for maternal education (8% total missing: 12% missing from African-born black, 4% missing from U.S.-born white, and 10% missing from U.S.-born black women), smoking during pregnancy (2% total missing: 2% missing from African-born black, 1% missing from U.S.-born white, and 3% missing from U.S.-born black women), and prenatal care adequacy measured by the Kotelchuck index (16% total missing: 21% missing from African-born black, 10% missing from U.S.-born white, and 19% missing from U.S.-born black women). Of note, pre-pregnancy BMI data was not collected on Washington State birth certificates prior to 2003; 33% of African-born women and approximately 50% of U.S.-born white and U.S.-born black women were missing this data. Therefore, all analyses involving pre-pregnancy BMI were limited to records from 2003-2013. In addition, data on the following perinatal outcomes were missing: PTB status in 2% of all records (5% among African born black, 1% among U.S. born white, and 1% among U.S. born black women), LBW status in 2% of all records (3% among African born black, 2% among U.S. born white, and 2% among U.S. born black women), and SGA status in 9% of all records (10% among African born black, 12% among U.S. born white, and 6% among U.S. born black women).

We initially compared differences in the baseline maternal demographic, behavioral, socioeconomic, prenatal, and delivery characteristics among births within the three categories of maternal birth country and race by performing bivariate chi-square analysis for categorical variables and t-tests and one-way analysis of variance for continuous variables. We then evaluated distribution of BTP intervals by mother's race and country of birth. To estimate the risk of short BTP or intermediate BTP interval among African-born black women, , we used logistic regression models with US-born White or US-born black women as reference groups. These models were adjusted for *a priori* identified potential confounders: maternal age, education, marital status, smoking status, delivery type, and parity in the first delivery of each birth pair. Among African-born black women, logistic (for dichotomous perinatal outcomes) and linear (for continuous perinatal outcomes) regression models were used to estimate associations of risk factors and adverse perinatal outcomes with short or intermediate BTP interval. These models were also adjusted for the potential confounders described above. We examined the effect of BTP interval on associations of maternal race and country of birth with perinatal outcomes by fitting two models (one with and the other without BTP interval as a covariate) and evaluating changes in the risk estimates. We also evaluated BTP interval as an effect modifier by estimating the risk of adverse perinatal pregnancy outcomes among African-born black women compared with U.S.-born white women or U.S.-born black women among groups stratified by short, intermediate, and normal BTP interval. In addition, the p-value of an interaction term was used to test statistical significance of multiplicative interaction in models that contain indicators for the exposure (African born black, US born white, or US born black), BTP intervals, and interaction of BTP with the exposure. All statistical analyses were conducted using STATA version 13.0 (College Station, TX) software. We used a p-value of <0.05 to determine statistical significance.

Results:

Selected characteristics of study participants (African-born black, U.S.-born white, and U.S.-born black women) are shown in **Table 1**. From the first pregnancies of each birth pair, African-born black women were likely to be older, less educated, underweight (BMI < 18.5), and multiparous (≥ 1 child), compared with U.S.-born white and U.S.-born black women. They also had higher rates of inadequate prenatal care and cesarean section deliveries. In the second pregnancies of each birth pair, African-born black women had higher rates of anemia compared with U.S-born white and black women. Rates of PTB, LBW and SGA among African-born black women were lower than U.S.-born black women and closer to rates among US-born white women (**Table 1**).

African-born black women had shorter mean BTP intervals compared with U.S.-born white and U.S.-born black women (**Table 2**). The frequency of short BTP interval (<6 months) was 10% for African-born black women, with women from Eastern Africa having the highest percentage of short BTP interval (11.4%), 4% for U.S.-born white women, and 7% for U.S.-born black women (p<0.001). **Table 2** also shows the percentage of women with long BTP intervals (≥ 60 months) by maternal birth country and race with U.S.-born black women having the highest proportion of long BTP intervals. However, long BTP intervals were not a focus of this study and thus were not included in other analyses. After adjustment, African-born black women have 3.44-fold (95% Confidence Interval (CI): 2.53-4.68) and 1.67-fold (95%CI: 1.26-2.21) higher odds of short BTP intervals compared with U.S.-born white and U.S.-born black women, respectively (**Table 3**). Similarly, African-born black women had 1.49-fold (95%CI: 1.28-1.74) and 1.60-fold (95%CI: 1.34-1.89) higher odds of intermediate (6 to 18 months) BTP intervals than U.S.-born white and U.S.-born black women, respectively (**Table 3**).

Compared with women from Central, Western, Northern, and Southern African, women from Eastern Africa had significantly higher risk for short (aOR 3.17; 95%CI: 1.92-5.24) and intermediate (aOR 1.29; 95%CI: 1.03-1.60) BTP intervals (**Table 4**). African-born black women had significantly lower risk for short BTP interval if they were ≥ 35 years old (aOR 0.59; 95%CI: 0.35-0.98), multiparous (aOR 0.73; 95%CI: 0.54-0.98), had an educational level greater than high school (aOR 0.52; 95%CI: 0.38-0.71), and had a cesarean delivery (aOR 0.61; 95%CI: 0.44-0.84) in the first pregnancy of each birth pair. Among these groups of women, lower risk for intermediate BTP was also observed although the estimates were not statistically significant (**Table 4**). When evaluating the association between short and intermediate BTP interval with adverse neonatal and maternal outcomes among African-born black women only, we observed a trend for higher odds of PTB, LBW, and maternal anemia among women with short BTP interval compared with women with normal BTP interval but this trend was not significant (**Table 5a**). African-born black women with intermediate BTP intervals had a 0.52 kg/m^2 significantly lower pre-pregnancy BMI than those with normal BTP intervals (**Table 5b**).

When compared to U.S.-born white women, African-born women had significantly higher risk for having LBW or SGA infants, infants with lower birth weight, and higher pre-pregnancy BMI (**Table 6**). On the other hand, African-born black women had significantly lower risk for PTB and having SGA infants, compared with U.S.-born black women. African-born women had significantly higher risk of anemia compared with either U.S.-born white or black women. Importantly, the estimates and significance of these associations did not change between models with and without BTP interval as a covariate (**Table 6**).

In stratified models, associations of maternal birth country and race with perinatal outcomes were similar across the three groups (short, intermediate, and normal BTP intervals) with the following exceptions (**Tables 7a and 7b**). The higher risk of having LBW infants among African-born black women, compared with U.S.-born white women was observed among women with normal BTP intervals (aOR 1.89; 95%CI: 1.10- 3.23). Similarly, higher pre-pregnancy BMI among African-born black women, compared with U.S.-born white women, was observed among women with intermediate BTP intervals (β-coefficient: 0.49; 95%CI: 0.09-0.88) and normal (β-coefficient: 0.68; 95%CI: 0.30-1.07) BTP intervals. While the risk of anemia among African-born black women, compared with U.S.-born white women, was higher in all three groups, estimates were substantially higher for women with short BTP (aOR 3.44; 95%CI: 1.80-6.59) intervals. On the other hand, the higher risk of anemia among African-born black women, compared with U.S.-born black women was observed among women with short (aOR 1.93; 95%CI: 1.20-3.10) and normal (aOR 1.43; 95%CI: 1.15-1.79) BTP intervals, but not women with intermediate BTP intervals (aOR 1.16; 95%CI: 0.90-1.49). Similarly, the higher birth weight of infants of African-born black women, compared with U.S.-born black women was observed only among women with intermediate (β-coefficient 48.34; 95%CI: 8.58-88.11) BTP intervals, but not women with short (β-coefficient 70.87; 95%CI: 3.87-145.60) or normal (aOR 31.64; 95%CI: -2.75-66.03) BTP intervals. In our regression models which assessed multiplicative interactions of BTP intervals and maternal birth country and race on perinatal outcomes, none of the interaction terms were statistically significant (results not included in Tables).

Discussion:

We found that African-born black women have approximately 3 and 1.5-fold higher odds of having short BTP intervals compared with U.S.-born white and U.S.-born black women, respectively. The majority of African-born women in our study (82%) were from Eastern Africa, and this group had the highest percentage of women with short BTP intervals compared with women born in other African regions. Among African-born black women, older age, higher educational status, multiparity, and history of cesarean delivery in prior birth were associated with lower risk for short BTP intervals. Despite a trend for positive relationships between short BTP interval and adverse neonatal and maternal pregnancy outcomes, we did not observe a significant association between short BTP interval and adverse neonatal and maternal pregnancy outcomes among African-born black women, except for a significant association between intermediate BTP interval and lower pre-pregnancy BMI. Adjusting for BTP did not appreciably alter associations of maternal birth country and race with perinatal complications; however, we found evidence for potential effect modification of associations of maternal birth country and race with perinatal complications by BTP intervals. To our knowledge, this is the first study exploring differences in BTP interval and risk factors for short BTP interval among African-born women in the U.S.

We chose to focus on the neonatal outcomes of preterm birth (PTB), low birthweight (LBW)/infant birthweight, and small for gestational age (SGA) specifically because these outcomes have been most commonly linked to short BTP interval in the literature and have significant repercussions for neonatal and childhood morbidity. Similarly, maternal anemia has been linked to short BTP intervals.[27] Additionally, we were interested in pre-pregnancy BMI and its relationship to short BTP interval because obesity and abnormally high pre-pregnancy BMI has been linked with both neonatal and maternal morbidity during pregnancy and labor.[28-30]

Our findings add to the published literature reporting differences in birth outcomes among immigrant women in industrialized countries. Previous studies of African immigrants, conducted in European countries, have shown that women from sub-Saharan Africa and African refugees have increased risk of perinatal morbidity and mortality when compared with women born in industrialized receiving countries.[9,31,32] For example, a systematic review by the Reproductive Outcomes and Migration (ROAM) research collaboration found that sub-Saharan African immigrants had greater risks for fetal and infant mortality and pre-term birth compared with women born in industrialized countries.[8] However, while many of these studies that compare immigrant groups with women born in industrialized countries did not differentiate the comparison groups by race, we used two categories of comparison groups to differentiate the effects of black race and immigrant status on perinatal outcomes. In our study, although African-born women had higher risk for LBW and SGA compared with U.S.-born white women, their risk for PTB and LBW was lower than that of U.S.-born black women. This finding is consistent with previous literature showing a lower risk of PTB and LBW among Sub-Saharan African-born and Carribean-born women compared with U.S.-born non-hispanic black women.[33] This phenomenon may be explained by a similar healthy immigrant effect which has previously been described among Hispanic immigrants to the U.S.[34,35] In addition, some investigators have proposed that selective migration of healthier women with positive health behaviors may contribute to more favorable health outcomes among foreign-born women compared with their U.S.-born counterparts.[36] Other factors that may be affecting the relationship between maternal birth country and race and perinatal outcomes in either a positive or negative way are social support and social ties.[37] Observational studies have cited social ties and social support from family and community as factors that may improve pregnancy outcomes.[38-40] While black race has been cited as a risk factor for PTB[41], LBW[42], stillbirth[43], and other adverse neonatal outcomes, our study results show that African-born black women in the U.S. have relatively improved pregnancy outcomes in comparison to U.S.-born black women. In our study, African-born black women were more likely to be married and less likely to smoke during pregnancy than U.S.-born black women. Cultural behaviors promoting health, social ties within close-knit African immigrant communities, and lower substance use disorders[44] may be protective for African-born black women in the antenatal and postnatal periods.

We found potential effect modification by BTP interval of the association between maternal birth country and race with neonatal and maternal pregnancy outcomes. The interaction term was not significant, possibly because of lack of study power or an interaction that is not happening on a multiplicative scale. When we stratified by BTP interval, the increased risk for LBW among African-born black women, compared with U.S.-born white women, was observed in the normal BTP interval group. The fact that either short or intermediate BTP intervals potentially elevate the risk of LBW among U.S. born whites may account for this observation. Another potential reason could be similarities in demographic or pregnancy characteristics that may contribute to higher risk for LBW among all women with short BTP interval (e.g. lower age, lower socioeconomic status, etc.). In addition, we found the higher risk of anemia among African-born black women compared with U.S.-born white and U.S.-born black women was most pronounced among those with short BTP intervals. A possible explanation for this difference is that among women with short BTP interval, African-born black women may have more depleted stores of nutrients, such as iron, compared with U.S.-born women.[27,45] Also, higher rates of cesarean section[10] and perineal lacerations[13] among African-born women may contribute to higher rates of anemia in this group compared with U.S.-born women.

The fertility rates for women in some African countries are as high as 6-8 live births per woman.[46,47] Women in some African countries have low contraceptive prevalence rates and high percentages of unmet need for contraception (i.e. the percentage of fertile, married women of reproductive age who do not desire pregnancy but are not using contraception).[48,49] In comparison, the fertility rate in the U.S. is approximately 2 live births per mother, and rates of contraceptive utilization among married women are 77%.[50,51] However, we do not have information on how fertility rates or rates of contraceptive use change among African-born women after immigration to the U.S. If patterns of high fertility and low contraceptive prevalence among African-born women persist after migration to the U.S., these behaviors may impact birth spacing and lead to shorter BTP intervals than those of U.S. born women. More research needs to be done to evaluate behavioral, social, and cultural factors that may affect birth spacing and family planning practices among African-born women.

There are several limitations in this study. Although African immigrants are a heterogeneous population, we combined African-born black women together in our dataset because of the limited numbers of women born in certain regions and countries of Africa and in order to increase power in the regression analyses to detect differences in rare perinatal outcomes among the exposure and comparison groups. Furthermore, the population of African-born black women in our dataset is mostly comprised of Eastern African immigrants, which is different from the general U.S. population of African immigrants. Therefore, findings from this study may not be generalizable to other settings in the U.S. Given the limitations of using birth certificate data, we did not have accurate information reflecting length of time in the U.S. or acculturation, which includes factors that may impact birth outcomes among immigrants. In addition, BTP intervals measure the time period between live birth and conception date of a subsequent pregnancy ending in live birth so this measurement does not include pregnancies ending in miscarriage (subclinical, clinical, or unreported miscarriage), but information about miscarriage is not available from birth certificate data. In addition, we were not able to assess unmeasured factors such as duration of breastfeeding after the first delivery, contraceptive use and duration, and pregnancy intention all of which could confound the associations between exposure and outcome.

The World Health Organization (WHO) recommends a BTP interval of greater than two years and less than five years due to the evidence that intervals less than 18 months are associated with increased risk of perinatal and maternal outcomes.[52] The findings from this study may inform family planning and perinatal counseling strategies for African-born immigrant women in the U.S. If African-born black women represent a high risk group for short BTP intervals, and short BTP intervals have been associated with adverse perinatal outcomes, public health and healthcare providers should focus more attention on counseling and education regarding pregnancy spacing in this population.

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Table 1. Selected maternal characteristics of study population[¥] by mother's race and country of birth.[¥]

	African-born black (n=3,312)		US-born white (n=7,839)		US-born black (n=7,833)	
Maternal characteristics*	n	%	n	%	n	%
Maternal age at delivery (mean, SD)	3309	27.6 (5.1)	7837	25.6 (5.4)	7830	22.3 (5.1)
Maternal age at delivery (yrs)						
≤ 19	150	4.5	1225	15.6	2783	35.5
20-34	2846	86.0	6172	78.8	4841	61.8
≥ 35	313	9.5	440	5.6	206	2.6
Mother's Education (yrs) (mean, SD)	2911	11.8 (3.1)	7528	13.6 (2.4)	7037	12.3 (2.0)
Mother's Education (yrs)						
< 9	370	12.7	61	0.8	124	1.8
9-12	1503	51.6	3048	40.5	4393	62.4
> 12	1038	35.7	4419	58.7	2520	35.8
Married	2443	74.1	5510	70.4	2222	28.4
Smoked during Pregnancy	13	0.4	1172	15.2	1063	14.0
Pre-pregnancy BMI (kg/m^2) (mean, SD)	1698	24.6 (5.0)	2671	25.8 (6.0)	2255	27.4 (7.0)
Pre-pregnancy BMI (kg/m^2)						
< 18.5	129	7.6	90	3.4	70	3.1
18.5-24.9	876	51.7	1391	52.3	946	42.1
25-29.9	465	27.4	657	24.7	586	26.1
≥ 30	226	13.3	522	19.6	645	28.7
Adequacy of Prenatal Visits[β]						
Inadequate	631	24.1	643	9.2	1227	19.4
Intermediate	571	21.8	1449	20.6	1431	22.6
Adequate	1055	40.3	3567	50.8	2411	38.1
Adequate Plus	360	13.8	1370	19.5	1260	19.9
Nulliparous	2121	64.7	6407	81.8	5719	73.3
Cesarean delivery	1011	30.5	1686	21.5	1714	21.9
Neonatal death[$]	13	0.4	84	0.5	100	1.3
PerInatal Outcomes[1]						
PTB[2]	178	5.6	452	5.8	759	9.8
LBW[3]	135	4.2	262	3.4	622	8.1
SGA[4]	322	10.8	435	6.3	1103	15.0
Maternal anemia	519	15.7	628	8.0	1110	14.2
Pre-pregnancy BMI (mean, SD)[5]	26.3 (5.2)		26.9(6.7)		29.3 (7.7)	

¥ Study population = cohort of African-born black women and U.S.-born non-Hispanic white and black women in Washington State delivering between 1992 and 2013.
* Numbers are calculated for first birth from each birth pair and may not add to totals because of missing data; percentages calculated with missing data excluded; p<0.001 for all comparisons
β Based on Kotelchuck Index
$ Neonatal death = infant death within the first 28 days of life
1 All perinatal outcomes are outcomes for second pregnancy of each birth pair
2 PTB = pre-term birth (birth prior to 37 completed weeks gestation)
3 LBW = low birthweight (birthweight < 2500 g)
4 SGA = small for gestational age (birthweight of infant < 10^{th} percentile for gestational age)
5 Pre-pregnancy BMI data was limited to pregnancies between 2003-2013

Table 2. Distribution of birth to pregnancy (BTP) intervals among study population[¥] by mother's race and country of birth.

		BTP interval (months)			
		< 6	6 to <18	18 to <60	≥ 60
	Mean (SD)	n (%)	n (%)	n (%)	n (%)
African-born women (n=3,312)	25.6 (23.7)	333 (10.0)	1343 (40.6)	1374 (41.5)	262 (7.9)
East Africa (n=2708)	25.0 (24.1)	309 (11.4)	1123 (41.5)	1066 (39.4)	210 (7.8)
Central Africa (n=50)	24.8 (19.1)	2 (4.0)	26 (52.0)	17 (34.0)	5 (10.0)
West Africa (n=436)	29.1 (22.3)	18 (4.1)	152 (34.9)	226 (51.8)	40 (9.2)
North Africa (n=107)	26.2 (17.8)	4 (3.7)	38 (35.5)	58 (54.2)	7 (6.5)
South Africa (n=11)	21.5 (8.1)	0 (0.0)	4 (36.4)	7 (63.6)	0 (0.0)
US-born white women (n=7,839)	32.1 (27.4)	333 (4.3)	2397 (30.6)	4185 (53.3)	924 (11.8)
US-born black women (n=7,833)	41.0 (35.5)	531 (6.8)	1859 (23.7)	3711 (47.4)	1732 (22.1)

¥ Study population = cohort of birth pairs to African-born women and U.S.-born non-Hispanic white and black women in Washington State delivering between 1992 and 2013.

Table 3. Association of mother's country of birth and race with short and intermediate birth to pregnancy (BTP) intervals.

	Birth to pregnancy intervals (months)			
	< 6[&]		6 to 18[&]	
	OR	95% CI	OR	95%CI
U.S.-born white women	Ref	--	Ref	--
African-born women	3.44	(2.53, 4.68)	1.49	(1.28, 1.74)
U.S.-born black women	Ref	--	Ref	--
African-born women	1.67	(1.26, 2.21)	1.60	(1.34, 1.89)

Note: p<0.001 for all OR on this table; OR= odds ratio; CI = confidence interval; Ref = reference group

*OR = Odds Ratio; analyses are adjusted for maternal age at delivery, mother's education, marital status, parity, neonatal death in previous birth, cesarean delivery in previous birth, and mother's smoking status during pregnancy in initial birth pairs

[&] short (<6 months) and intermediate (6-18 months) BTP intervals were compared to normal (18-60 months) BTP intervals.

Table 4. Risk factors for short (< 6 months) and intermediate (6-18 months) birth to pregnancy (BTP) intervals among African-born black women delivering infants in Washington from 1992-2013.

	Short BTP Interval[&] (<6 months)					Intermediate BTP Interval[&] (6 - 18 months)				
Maternal characteristics*	n	%	Odds Ratio[+]	95% CI	p-value	n	%	Odds Ratio[+]	95% CI	p-value
Region of Birth										
East Africa	312	21.9	3.17	(1.92, 5.24)	<0.001	1158	51.0	1.29	(1.03, 1.60)	0.025
Other Regions	21	7.5	Ref[1]	--	--	185	41.7	Ref[1]	--	--
Maternal age at delivery (yrs)										
≤ 19	27	33.8	1.65	(0.96, 2.84)	0.068	52	49.5	0.95	(0.62, 1.45)	0.799
20-34	283	19.4	Ref[1]	--	--	1151	49.5	Ref[1]	--	--
≥ 35	23	13.7	0.59	(0.35, 0.98)	0.041	137	48.6	0.91	(0.69, 1.19)	0.477
Mother's Education (yrs)										
≤ 12	219	23.3	Ref[1]	--	--	786	52.2	Re	--	--
> 12	72	12.6	0.52	(0.38, 0.71)	<0.001	400	44.4	0.73	(0.61, 0.87)	0.001
Marital Status										
Single	88	19.3	Ref[1]	--	--	333	47.6	Ref[1]	--	--
Married	243	19.5	1.17	(0.87, 1.59)	0.295	1003	50.0	1.18	(0.98, 1.43)	0.080
Smoked during Pregnancy										
No	329	19.7	Ref[1]	--	--	1316	49.6	Ref[1]	--	--
Yes	0	0	--	--	--	5	41.7	0.52	(0.13, 2.12)	0.365
Pre-pregnancy BMI (kg/m^2)[β]										
< 18.5	19	27.9	1.23	(0.64, 2.36)	0.529	58	54.2	1.08	(0.71, 1.64)	0.728

18.5-24.9	97	21.0	Ref[1]	--	--	383	51.1	Ref[1]	--	--
25-29.9	48	19.5	0.95	(0.63, 1.42)	0.806	207	51.1	1.00	(0.78, 1.30)	0.962
≥ 30	32	27.6	1.58	(0.91, 2.51)	0.114	102	54.8	1.13	(0.81, 1.58)	0.480
Adequacy of Prenatal Visits[2]										
Inadequate	73	22.9	1.10	(0.76, 1.58)	0.617	255	50.9	1.00	(0.79, 1.27)	0.987
Intermediate	54	18.4	0.89	(0.60, 1.32)	0.559	231	49.0	0.95	(0.75, 1.21)	0.691
Adequate	114	20.9	Ref[1]	--	--	446	50.8	Ref[1]	--	--
Adequate Plus	43	21.8	1.16	(0.76, 1.78)	0.494	135	46.7	0.83	(0.62, 1.10)	0.192
Number of previous live born infants (Parity)										
0	225	20.6	Ref[1]	--	--	875	50.23	Ref[1]	--	--
≥ 1	105	17.5	0.73	(0.54,0.98)	0.042	451	47.6	0.85	(0.71, 1.02)	0.077
Cesarean delivery										
No	259	21.7	Ref[1]	--	--	922	49.7	Ref[1]	--	--
Yes	74	14.4	0.61	(0.44, 0.84)	0.002	421	48.9	0.94	(0.79, 1.13)	0.506
History of fetal death[$]										
No	361	17.6	Ref[1]	--	--	1338	49.4	Ref[1]	--	--
Yes	3	37.5	3.32	(0.83, 13.2)	0.090	5	50.0	1.12	(0.28, 4.43)	0.875

Note: Numbers may not add to totals because of missing data; percentages calculated with missing data excluded

* Maternal characteristics are taken from first delivery in each birth pair

[&] Analyses for pre-pregnancy BMI data was limited to pregnancies between 2003-2013

[1]Ref=reference group

[2] Other Regions = Central, Western, Northern, and Southern Africa (defined by UN designated regions of Africa)

[+] OR= odds ratio; calculated when controlling for mother's African region of birth, maternal age at delivery, mother's education, marital status, and parity recorded in first birth

Table 5. Risk of adverse perinatal outcomes by BTP interval among African-born black women (N=3,312).

a. Comparing odds ratios for dichotomous outcomes at index birth (second birth of each pair)

	PTB[2]					LBW[3]					SGA[3]					Maternal Anemia				
BTP int. (months)[1]	n	%	OR[+]	95 %CI	p-value	n	%	OR[+]	95 %CI	p-value	n	%	OR[+]	95 %CI	p-value	n	%	OR[+]	95 %CI	p-value
< 6	20	6.4	1.23	(0.68, 2.25)	0.50	16	4.8	1.09	(0.42, 2.87)	0.86	29	9.2	0.85	(0.54, 1.34)	0.49	63	18.9	1.15	(0.82, 1.63)	0.41
6 to < 18	66	5.2	0.93	(0.64, 1.36)	0.72	49	3.8	1.02	(0.56, 1.84)	0.96	129	10.6	0.99	(0.75, 1.31)	0.95	196	14.6	0.87	(0.69, 1.09)	0.22
18 to 60	73	5.5	Ref[4]	--	--	56	4.2	Ref[4]	--	--	134	11.0	Ref[4]	--	--	218	15.9	Ref[4]	--	--

Note: Numbers may not add to totals because of missing data; percentages calculated with missing data excluded

[+] OR= odds ratio; all models adjusted for mother's African region of birth, maternal age at delivery, mother's education, marital status, and parity recorded in first birth

[1] BTP int. = Birth to pregnancy interval

[2] PTB = pre-term birth outcome; additionally adjusted for history of PTB in first birth of pair

[3] LBW (low birthweight) & SGA (small for gestational age) additionally adjusted for gestational age at delivery

[4] Ref=reference group

b. Comparing β-coefficients for continuous outcomes at index birth (second birth of each pair)

	Infant birthweight (g)*			Maternal pre-pregnancy BMI (kg/m^2)*		
BTP interval (months)[1]	coef+	95%CI	p-value	coef+	95%CI	p-value
< 6	-39.0	(-94.47, 16.40)	0.17	-0.33	(-0.96, 0.30)	0.31
6 to < 18	-15.0	(-52.17, 22.16)	0.43	**-0.52**	**(-0.91, -0.13)**	**0.01**
18 to < 60	Ref[2]	--	--	Ref[2]	--	--

Note: Numbers may not add to totals because of missing data; percentages calculated with missing data excluded

+ coef= β-coefficient; all models adjusted for mother's African region of birth, maternal age at delivery, mother's education, marital status, and parity recorded in first birth

* infant birthweight outcome was additionally adjusted for gestational age & maternal pre-pregnancy BMI outcome was additionally adjusted from maternal pre-pregnancy BMI for first birth of each birth pair

1 BTP int. = Birth to pregnancy interval

2 Ref=reference group

Table 6. Risk of Perinatal Outcomes among African-born black women compared to U.S.-born white and U.S.-born black women with (Model 1) and without (Model 2) adjustment for birth to pregnancy (BTP) interval.

	African-born vs. U.S.-born White[&]				**African born vs. U.S.-born Black[&]**			
Dichotomous outcomes	Model 1[1]		Model 2[2]		Model 1[1]		Model 2[2]	
Neonatal outcomes	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
PTB	0.96	(0.77, 1.19)	0.98	(0.78, 1.22)	0.62[#]	(0.50, 0.77)	0.64[#]	(0.52, 0.80)
LBW	1.46[#]	(1.04, 2.05)	1.46[#]	(1.04, 2.05)	0.77	(0.56, 1.06)	0.79	(0.57, 1.08)
SGA	2.17*	(1.79, 2.63)	2.17*	(1.79, 2.63)	0.81[#]	(0.68, 0.96)	0.84[#]	(0.70, 0.99)
Maternal outcomes								
Anemia	1.99*	(1.71,2.31)	2.03*	(1.75, 2.35)	1.38*	(1.19, 1.59)	1.38*	(1.19, 1.60)
Continuous outcomes	Coef	95% CI	Coef	95% CI	Coef	95% CI	Coef	95% CI
Infant birthweight (g)	-136.48*	(-157.65, -115.32)	-136.36*	(-157.68, -115.04)	45.44*	(22.25, 68.64)	45.59*	(22.16, 69.01)
Maternal pre-pregnancy BMI (kg/m^2)	0.45*	(0.18, 0.71)	0.54*	(0.28, 0.81)	-0.14	(-0.46, 0.17)	-0.02	(-0.34, 0.29)

[&] Second order births to African-born women were compared to second order births to U.S.-born white women (reference group) and U.S.-born black women (reference group).
[1] Model 1 is adjusted for maternal age at delivery, mother's education, marital status, smoking status, C-section, and parity recorded from first pregnancy; LBW and infant birthweight outcomes were additionally adjusted for gestational age & pre-pregnancy BMI in second pregnancy was adjusted for pre-pregnancy BMI in first pregnancy
[2] Model 2 is Model 1 + adjustment for BTP interval
[#] p<0.05
* p<0.001

Table 7. Stratified analyses of association between perinatal outcomes and maternal birth country & race by short and intermediate BTP interval

a. Risk of adverse perinatal outcomes for African-born black women compared with U.S. born white women

African-born black women vs. U.S.-born white women						
	Short BTP Interval (<6 months)		Intermediate BTP Interval (6 to < 18 months)		Normal BTP Interval (18 to < 60 months)	
Dichotomous Outcome	OR[1]	95% CI	OR[1]	95% CI	OR[1]	95% CI
PTB	0.86	(0.41, 1.80)	0.84	(0.59, 1.20)	1.15	(0.83, 1.61)
LBW	1.02	(0.28, 3.73)	1.38	(0.78, 2.42)	1.89*	(1.10, 3.23)
SGA	2.09	(0.92, 4.74)	1.97*	(1.42, 2.73)	2.31*	(1.75, 3.06)
Anemia	3.44*	(1.80, 6.59)	1.81*	(1.40, 2.32)	2.10*	(1.70, 2.60)
Continuous Outcome	Coef[2]	95% CI	Coef[2]	95% CI	Coef[2]	95% CI
Infant birthweight (g)	-139.66*	(-217.96, -61.35)	-132.75	(-167.64, -97.86)	-136.02*	(-167.82, -104.22)
Maternal pre-pregnancy BMI (kg/m^2)	0.17	(-0.79, 1.12)	0.49*	(0.09,0.88)	0.68*	(0.30, 1.07)

Note: Odds ratios (OR) are adjusted for maternal age at delivery, mother's education, marital status, smoking status, C-section, and parity recorded from first pregnancy; PTB in second pregnancy adjusted for history of PTB in first pregnancy, LBW and infant birthweight outcomes were additionally adjusted for gestational age & pre-pregnancy BMI in second pregnancy was adjusted for pre-pregnancy BMI in first pregnancy of birth pairs

[1] OR = odds ratio for logistic regression

[2] Coef = β-coefficient for linear regression

* p-value <0.05

b. Risk of adverse perinatal outcomes for African-born black women compared with U.S.-born black women

African-born black women vs. U.S.-born black women						
	Short BTP Interval (<6 months)		Intermediate BTP Interval (6 to < 18 months)		Normal BTP Interval (18 to < 60 months)	
Dichotomous Outcome	OR[1]	95% CI	OR[1]	95% CI	OR[1]	95% CI
PTB	0.44*	(0.24, 0.83)	0.70	(0.48, 1.01)	0.64*	(0.47, 0.88)
LBW	0.64	(0.20, 2.07)	0.79	(0.46, 1.37)	0.95	(0.59, 1.55)
SGA	0.74	(0.39, 1.39)	0.80	(0.59, 1.06)	0.87	(0.67, 1.11)
Anemia	1.93*	(1.20, 3.10)	1.15	(0.90, 1.49)	1.43*	(1.15, 1.79)
Continuous Outcome	Coef[2]	95% CI	Coef[2]	95% CI	Coef[2]	95% CI
Infant birthweight (g)	70.87	(-3.87, 145.60)	48.34*	(8.58, 88.11)	31.64	(-2.75, 66.03)
Maternal pre-pregnancy BMI (kg/m^2)	0.25	(-0.66, 1.17)	-0.12	(-0.59, 0.35)	0.08	(-0.37, 0.52)

Note: Odds ratios (OR) are adjusted for maternal age at delivery, mother's education, marital status, smoking status, C-section, and parity recorded from first pregnancy; PTB in second pregnancy adjusted for history of PTB in first pregnancy, LBW and infant birthweight outcomes were additionally adjusted for gestational age & pre-pregnancy BMI in second pregnancy was adjusted for pre-pregnancy BMI in first pregnancy of birth pairs

[1] OR = odds ratio for logistic regression

[2] Coef = β-coefficient for linear regression

* p-value <0.05