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Short Interpregnancy Interval Associated with Preterm Birth in US Adolescents

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Abstract

A short interpregnancy interval (IPI) is a risk factor for preterm delivery among women of reproductive age. As limited data exist concerning adolescents, we aimed to examine the association between short IPIs and preterm birth among adolescents using a majority of US births. Using 2007s2008 US natality data, we assessed the relationship between IPIs <3, 3–5, 6–11, and 12–17 months and moderately (32–36 weeks) and very (<32 weeks) preterm singleton live births among mothers <20 years, relative to IPIs 18–23 months. Adjusted odds ratios (aORs) and 95 % confidence intervals (95 % CIs) adjusted for maternal race, age, previous preterm deliveries, marital status, smoking and prenatal care were determined from a multivariable multinomial logistic regression model. In 2007–2008, there were 85,077 singleton live births to women aged <20 who had one previous live birth, 69 % of which followed IPIs 226518 months. Compared with IPIs 18–23 months, short IPIs were associated with *moderately* preterm birth for IPIs <3 months

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(aOR 1.89, 95 % CI 1.70–2.10), 3–5 months (aOR 1.33, 95 % CI 1.22–1.47), and 6–12 months (aOR 1.11, 95 % CI 1.02–1.21). IPIs <3 and <6 months were also associated with *very* preterm birth, with aORs of 2.52 (95 % CI 1.98–3.22) and 1.68 (95 % CI 1.35–2.10) respectively. Many adolescent mothers with repeat births have short IPIs, and shorter IPIs are associated with preterm birth in a dosedependent fashion. Increasing adolescent mothers' use of effective contraception postpartum can address both unintended adolescent births and preterm birth.

Keywords

Interpregnancy interval; Preterm birth; Teen pregnancy; Birth intervals; Premature birth; Pregnancy in adolescence; Contraception; Rapid repeat pregnancy

Introduction

The teen birth rate in the United States remains among the highest in the developed world [1]. Between 300,000 and 400,000 children are born annually to adolescent mothers aged 19 or below in the US, with lower rates in recent years [2–5]. Around 18 % are repeat births [2–5]. Adolescents have a higher risk of preterm birth, with 19.0 and 12.7 % of all births being preterm in <15-year olds and 15- to 19-year olds, respectively, compared with just below 11 % among women in their twenties [4]. Among adolescent mothers with repeat births, one factor that might increase the risk for preterm birth may be if the second pregnancy follows shortly after the first birth. A short interpregnancy interval (IPI) is a known risk factor for preterm birth for women in general [6, 7], but there are limited data concerning adolescents; a study of adolescents in Milwaukee found that IPIs of <3 and 3–5 months were associated with preterm birth [8].

Prevention of unintended pregnancies among US adolescents and prevention of preterm birth are both national priorities [9]. Adolescent mothers are less likely than those who delay childbearing to finish high school and to complete 2 years of post-secondary education. Children of adolescent mothers are also less likely to finish high school, and girls are more likely to become teen mothers themselves compared with girls of mothers who delayed childbearing [10].

Most adolescent pregnancies are unintended; estimates range from 73 to 82 % for 15- to 19-year-olds [11, 12], although one study shows that more than a third of women with a rapid repeat pregnancy (RRP—a pregnancy within 24 months of the resolution of the prior pregnancy) reported the second pregnancy as intended [13]. Adolescent RRP is associated with younger age at the first birth, lower socioeconomic status, not using long-acting reversible contraception (LARC) methods, and second pregnancy intended by the partner [13–15]. Preterm birth has several impacts for the child. In the US, 34.3 % of infant deaths are attributable to prematurity [16]. Preterm infants are vulnerable to complications both soon after birth as well as in the long term. The societal cost of preterm birth in the United State is estimated to be more than $26 billion annually [17, 18].

Caring for more than one child is likely already difficult for adolescent mothers, and a child born prematurely would be an additional challenge. In the US, we quantify the range of IPIs

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among adolescents at a near-national level and their association with both moderately preterm and very preterm birth, using national level birth data from the US National Center for Health Statistics (NCHS).

Methods

We used vital registration birth data for 2007 and 2008, available from the NCHS, the most recent data available for this type of analysis. The US Standard Certificate of Live Birth was revised in 2003 to include the month and year of the last live birth, allowing for calculation of IPI. In 2007, 22 states had adopted the revision (53 % of all US births),[1] and by January 1, 2008, 27 states used the revised version (65 % of all US births).[2] Prior to 2007, an insufficient number of US birth certificates included the date of last live birth to be included in the analysis. The dataset is publicly available and de-identified, and ethical review by an institutional review board was not required.

We restricted the analysis to singleton second live births—defined as 'second' births—to women aged <20 years. We excluded multiple births and births that were to women who already had more than one previous birth or to women who had a previous pregnancy that did not result in a live birth. The IPI was computed as the time period between the first and second deliveries, minus the obstetric estimate [19] of the gestational age (GA) of the second infant [20]. As only the month and year of the births were available, the day was assumed to be the fifteenth day of the month in both cases for all records. We excluded women who had implausible IPIs (IPIs that were negative or shorter than 30 days).

IPIs were categorized into seven mutually exclusive levels: <3, 3–5, 6–11, 12–17, 18–23, 24–36, and >36 months; the 18–23 month interval was used as the reference category based on convention in the literature as to the risk of preterm birth being the lowest in this range of IPIs [6]. Births were categorized as 'moderately preterm' or 'very preterm' if the GA was between 32 and 36 weeks or below 32 weeks, respectively. Births with a GA of 37 weeks or more were considered 'term.'

We evaluated covariates based on availability and quality of the information on the birth certificate and plausible association with preterm birth. These include maternal age at first and second birth, maternal race/ethnicity, marital status at second birth, previous preterm birth (GA <37 weeks), prenatal care utilization prior to the second birth, and smoking. Maternal race/ethnicity represents the self-reported race of the mother and, for the purposes of this analysis, was categorized as 'Non-Hispanic White,' 'Non-Hispanic Black,' 'Hispanic,' and 'Other.' Birth outcomes are well known to vary by race/ethnicity, particularly between black and white women in the US [21]. To control for prenatal care utilization, we computed the Adequacy of Prenatal Care Utilization (AP-NCU) Index [22].

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[1]Twenty-two states and Puerto Rico had implemented the revised birth certificate as of January 1, 2007: California, Colorado, Delaware, Florida, Idaho, Indiana, Iowa, Kansas, Kentucky, Nebraska, New Hampshire, New York state (excluding New York City), North Dakota, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Washington, and Wyoming.

[2]Twenty-seven states and Puerto Rico had implemented the revised birth certificate as of January 1, 2008: California, Colorado, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Michigan, Montana, Nebraska, New Hampshire, New Mexico, New York (including New York City), North Dakota, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Washington, and Wyoming.

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We did not have access to any of the information on the birth certificate of the first birth. Dummy variables were created for observations with missing data on covariates.

We first performed bivariate analysis to assess the association between IPI and preterm birth as well as the association between each covariate and preterm birth independently. Results are expressed as odds ratios (ORs) and their 95 % confidence intervals (95 % CI). We also carried out bivariate analysis of the association between IPI and preterm birth stratified by race/ethnicity and by previous preterm birth to look for effect modification. Multinomial logistic regression models were constructed to assess the association between the different categories of IPIs and the different categories of GA of the second birth (<32, 32–36 and >37 weeks). In multivariable analysis, we fitted two separate models, each including all covariates (IPI, race/ethnicity, marital status, previous preterm birth, prenatal care utilization, and smoking) together with *either* age at first birth *or* age at second birth. Only age at second birth remained significant in multivariable analysis, and hence this model was chosen as the final model. Results are expressed as adjusted odds ratios (aOR) and their 95 % CIs. $P <$ 0.05 are considered statistically significant.

In subgroup analysis, we stratified the bivariate analysis by age at first birth (<16, 16, and 17). In further subgroup analysis, only looking at short IPI, we restricted the multivariable model to exclude women who had their first birth at an age where they would be too old to have a second birth within the reference IPI (18–23 months) before the age of 20.

Results

In 2007 and 2008, 891,616 live births to women aged 19 and below were recorded in the US, representing 10.4 % of all US births in those years. Of all these adolescent births, 10.8 % were preterm, including 9.9 % of singleton births. Around a fifth (19 %) of all births to adolescents were repeat births. Of these repeat adolescent births, a majority (61 %) occurred in states that had implemented the revised birth certificate, allowing for calculation of the IPI from the field ‘date of last live birth.’ Out of these births, we included in the analysis those 85,077 births (79.4 %) that were singleton births to a mother with one previous live birth, thus excluding multiple births and higher order births. Plausible IPIs could be calculated for 79,081 (93 %) of included births based on presence of information on the month and year of the last live birth, GA of the second birth, and the IPI not being shorter than 30 days (Fig. 1).

Of births included in the analysis, 8,733 (11 %) were preterm; 7,451 (9.4 %) were moderately preterm (GA 32–36 weeks) and 1,282 (1.6 %) were very preterm (GA <32 weeks) (Table 1). Almost half (38,636) were conceived within a year of the first birth, with 6.6 % having an IPI of <3 months and 15.1 % an IPI of 3–5 months. Women with missing or implausible IPI information were more likely to have had a moderately preterm infant (10.4 vs. 9.4 %) or a very preterm infant (3.3 vs. 1.6 %) compared with those included in the analysis.

The majority of women were aged 15–17 at their first birth and 18–19 at the second birth. The majority (79.0 %) of women were unmarried, around 15 % of women smoked during some or all of their pregnancy, and 2.6 % of women had a preterm first birth.

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Adolescents of Hispanic origin accounted for 45.3 % of all births included in our analysis. White and black adolescents accounted for 32.0 and 20.3 % of births, respectively. Black teens had a higher proportion of preterm births, with 12.5 and 2.7 % of births being moderately or very preterm, compared with 9.3 and 1.5 % for white adolescents. Hispanic mothers had the lowest proportion of preterm birth with 8.2 and 1.3 % of births being moderately preterm or very preterm, respectively. There were no significant differences between racial/ethnic groups in the likelihood of a short IPI, with 23.4, 22.3, and 20.3 % of second births having an IPI of <6 months among white, black and Hispanic women, respectively (data not shown).

Bivariate Analysis

Bivariate analysis of the association between IPI and moderately and very preterm birth shows a statistically significant, time-dependent association (Table 2). Compared with IPIs of 18–23 months, IPIs of <3 months were associated with moderately (OR 1.97, 95 % CI 1.77–2.18) and very preterm birth (OR 2.77, 95 % CI 2.18–3.52). IPIs of 3–5 months were also significantly associated with moderately preterm birth (OR 1.39, 95 % CI 1.27–1.52) and very preterm birth (OR 1.84, 95 % CI 1.48–2.28). The association was still statistically significant for IPIs of 6–11 months as compared with IPIs 18–23 months. For IPIs longer than 23 months, the only significant association observed was between IPIs >36 months and very preterm birth (OR 1.73, 95 % CI 1.30–2.30). Table 2 also shows bivariate associations between duration of IPI and other covariates such as race, where black race and previous preterm birth were associated with preterm birth.

In bivariate analysis stratified by race/ethnicity, the associations of IPIs <3 months and moderately preterm birth did not vary a great deal with ORs of 1.78 (95 % CI 1.45–2.19), 1.92 (95 % CI 1.60–2.31), and 2.03 (95 % CI 1.71–2.39) for non-Hispanic blacks, non-Hispanic whites and Hispanics, respectively. For very preterm birth, the associations with IPI of <3 months for non-Hispanic blacks (OR 3.04, 95 % CI 2.03–4.57), Hispanics (OR 2.94, 95 % CI 1.96–4.42), and non-Hispanic whites (OR 2.37, 95 % CI 1.51–3.72) were considered to be similar enough that we did not stratify the multivariable analysis (data not shown).

Figure 2 shows the relationship between IPI and preterm birth graphically with IPIs divided into monthlong intervals. There was a J-shaped, time-dependent relationship between IPI length and preterm birth, with preterm birth more likely at shorter IPIs, declining gradually until around 20 months, and remaining relatively flat until rising again at an IPI of around 35 months.

Multivariable Analysis

In multivariable analysis, the association between IPI and preterm birth remained time-dependent, with the shortest IPI (<3 months) having the strongest association with preterm birth with aORs of 1.89 (95 % CI 1.70–2.10) for moderately preterm birth and 2.52 (95 % CI 1.98–3.22) for very preterm birth relative to IPIs of 18–23 months. For IPIs of 3–5 months, the aOR for the association with moderately preterm birth was 1.33 (95 % CI 1.22–1.47) and for very preterm birth, 1.68 (95 % CI 1.35–2.10). The 95 % CIs did not overlap

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between the two shortest IPI intervals for either preterm or very preterm birth. The association between IPIs >36 months and very preterm birth remained significant (aOR 1.62, 95 % CI 1.22–2.17). Most covariates remained similar in direction and magnitude to their bivariate results.

Subgroup Analysis

In bivariate subgroup analysis stratified by age at first birth, results were similar to the main analysis among adolescents aged 16–17. Among adolescents <16, IPIs 3–5 and 6–11 months were associated with moderately preterm birth, but the results for IPIs <3 months and for very preterm birth are unreliable due to a small sample in this age group (results not shown).

In the multivariable subgroup analysis (excluding women who had their first birth at an age where they would be too old to have a second birth within the reference IPI before the age of 20), the association between IPI and moderately preterm birth remained very similar in direction and magnitude, although results were not significant for IPIs longer than 6 months, but became significant for IPIs 12–17 months. The association between IPI and very preterm birth also remained similar, although results for IPIs <3 months were no longer statistically significant due to small sample size (data not shown).

Discussion

This report shows a statistically significant, time-dependent relationship between interpregnancy intervals shorter than 12 months and moderately and very preterm birth among US adolescents. In multivariable analysis the association persists for IPIs <12 months and moderately preterm birth, and IPIs <6 months and very preterm birth, controlling for covariates known to be associated with preterm birth such as race/ethnicity, previous preterm birth and age at second birth. These covariates were independently associated with preterm birth in our analysis.

We were only able to identify one previous report concerning the association between IPI and preterm birth in teens, which found that IPIs of <3 and 3–5 months were associated with preterm birth (<37 weeks) with adjusted odds ratios of 2.04 and 2.36, respectively, compared with IPIs of >18 months [8]. A recent meta-analysis and a recent overview of publications on IPI and preterm birth were not able to identify any additional studies concerning adolescents [6, 7]. Other previous studies on IPI and preterm birth have included all women of reproductive age. The meta-analysis of eight such studies found that IPIs of <6 months were associated with preterm birth with a pooled unadjusted odds ratio of 1.77 (95 % CI 1.54–2.04) and a pooled adjusted odds ratio of 1.4 (CI 1.24–1.58) compared with IPIs of 18–23 months [6]. Our results confirm that short IPI is independently associated with preterm birth among adolescents with magnitudes similar to those previously reported.

Uniquely, we show that short IPI is statistically significantly associated with very preterm birth (<32 weeks) in teens, which has not been demonstrated previously among adolescents. A prior analysis of US vital records data from 1990 to 1993 found that teens with IPI <6 months had higher occurrence of very preterm birth than those with IPIs >6 months, although no test for statistical significance was performed [23]. Previous studies on women

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of any reproductive age have found adjusted ORs ranging from 1.35 to 2.2 for the association between IPI <6 months and very preterm birth [24, 25, 26], which are similar to our results.

Previous studies have identified a J-shaped relationship between IPI and preterm birth with both short and long IPIs being associated with preterm birth [6, 7]. Our results suggest a similar relationship with long IPI, although this result is likely biased in that only adolescents who were very young at their first birth can have a repeat pregnancy following a long IPI while <20. The etiology of the association between longer IPIs and preterm birth is unclear [27] and the importance uncertain.

Our results for the association between different covariates and preterm birth are consistent with previous reports, with younger adolescents and black adolescents being more likely to give birth to preterm infants [4, 28]. In previous reports, the association of IPI and preterm birth has largely been found to be similar for black and white women of reproductive age [6], which is in agreement with our results. Other reports have however observed short IPIs to be more common among African-American women [7], but we did not observe any differences of note in the proportion of short IPIs between black and white adolescents (data not shown).

The relationships among age, race/ethnicity, outcome of the first pregnancy, intendedness, IPIs, and pregnancy outcomes are complex [29]. A prior intended pregnancy has been shown to be associated with a subsequent RRP, whereas other studies did not find such an association [14]. Younger teens with a RRP were more likely to report it as intended [14]. In another study, short IPIs were associated with the second pregnancy being unintended [30]. Vital records do not include pregnancy intention information, so we were unable to explore these relationships.

Limitations

We considered limitations that could have influenced our findings. We were only able to include births to women residing in states using the revised birth certificate, representing 61 % of repeat births to women aged 19 years or below in 2007–2008. Although Hispanic groups are overrepresented and non-Hispanic white and non-Hispanic black births are underrepresented in states that have adopted the revised birth certificate [31], we have no reason to believe that the association between IPI and preterm birth would be any different for adolescents in states that have not adopted the revised birth certificate. Secondly, we were unable to control for socioeconomic status as such data are not available in the NCHS natality files. Thirdly, we were not able to include women who had a previous pregnancy not resulting in a live birth, as this information is not recorded on the birth certificate and thus we are not able to comment on the association between a short IPI following abortion or stillbirth and preterm birth. It is possible that some women with longer IPIs had an abortion or a stillbirth between their first and second live births and had a de facto shorter IPI, which could have biased our results towards the null. Fourthly, as teens with a longer time between first and second births would no longer be under age 20 at the time of the second birth, longer IPIs are systematically excluded from the sample. We have addressed this in two subgroup analyses but did not find that it had an impact on the association between short IPI

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and preterm birth. However, this might explain why we did not see an association between longer IPIs and preterm birth among younger adolescents. Finally, vital records data only include year and month of delivery, which means that we could have misclassified IPIs by up to a month. We believe that such misslcassification would occur at random and not bias our results.

Implications

Prevention of unintended teen pregnancy and prevention of preterm birth are both national public health priorities which can be partly addressed through helping adolescents who have already given birth delay a second pregnancy. There is a need to focus on increasing access to and use of contraception among sexually active teens, potentially delaying further sexual activity, as well as addressing the broader social determinants of teen pregnancy.

Adolescents face a multitude of barriers to accessing contraception including a lack of insurance coverage, inadequate knowledge about methods, health systems barriers such as limited clinic opening hours and inadequate provider knowledge and attitudes [32]; thus, the immediate postpartum period presents a unique opportunity. Adolescents should be offered an array of choices, as well as possibly delaying sexual activity, with a discussion of advantages and disadvantages of each method. Importantly, such discussions should include the recommendation of LARC methods—intrauterine devices (IUDs) and contraceptive implants—which have been shown to be more than 20 times more effective in preventing pregnancy than the oral contraceptive pill, the contraceptive patch, and the contraceptive vaginal ring [33]. LARC methods have also been shown to be more effective in reducing the risk of RRP [15, 34, 35], in particular if initiated immediately postpartum [36]. The American College of Obstetricians and Gynecologists recommends LARC as a first-line choice for adolescents [37, 38]. Twelvemonth continuation rates of LARC methods among women aged 14–19 have been shown to exceed 80 %, compared with 44 % for non-LARC methods [39].

Social and structural determinants could lead some adolescents to choose childbearing when they perceive that few other opportunities exist [40]. The proportion of adolescents who choose childbearing for these reasons might be particularly high among those choosing to carry a *second* pregnancy to term. In one study more than a third of RRP among adolescents were intended [13]. Addressing this portion of RRP among adolescents requires different approaches including focusing on the potential adverse health consequences of closely spaced births [13]. Better access to contraception for this group might at the very least serve to lengthen the interval between one pregnancy and the next and therefore reduce the risk of preterm birth.

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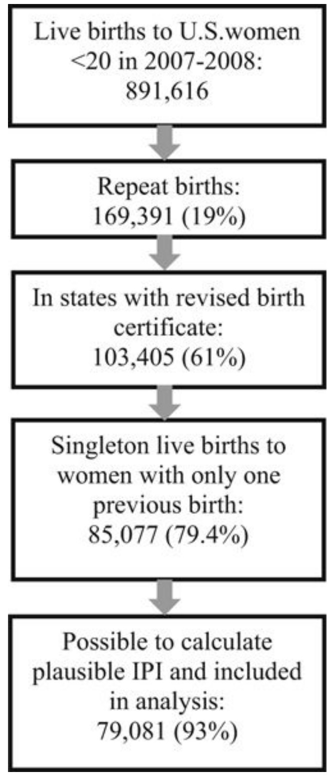

Fig. 1.

Flowchart of process of inclusion of observations from NCHS vital statistics data into final data set for analysis

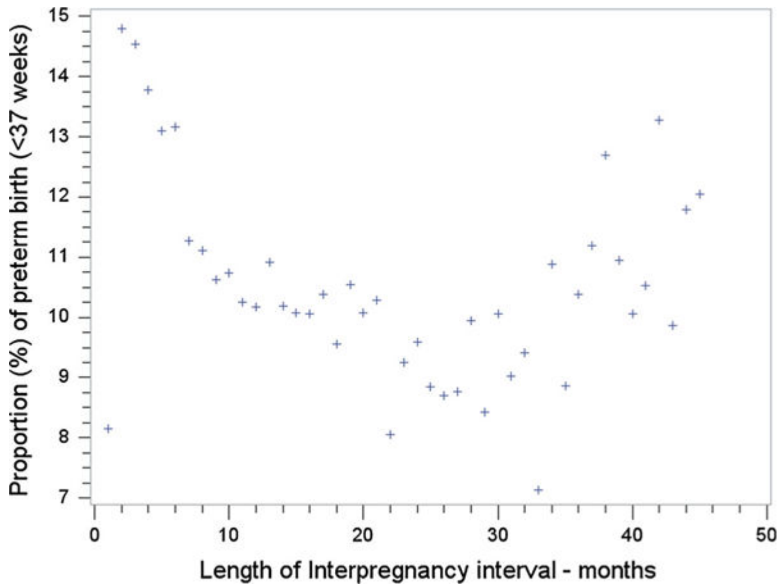

Fig. 2.

Risk for premature birth (<37 weeks) by different length of interpregnancy interval in months. This graph show the proportion of births being preterm (<37 weeks of gestation) among all births with the same IPIs calculated to the nearest month, from IPIs of 1 month to IPIs of 45 months

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Table 1

Gestational age distribution of second adolescent births by maternal risk factors, US, 2007–2008

Maternal risk factor	Gestational age of second birth (weeks)							
	Overall		>37		32–36		<32	
	n	%[a]	n	%[b]	n	%[b]	n	%[b]
Totals	79,081		70,348	89.0	7,451	9.4	1,282	1.6
IPI (months)								
<3	5,222	6.6	4,298	82.3	767	14.7	157	3.0
3–5	11,972	15.1	10,409	86.9	1,311	11.0	252	2.1
6–11	21,442	27.1	19,126	89.2	1,994	9.3	322	1.5
12–17	15,831	20.0	14,239	89.9	1,359	8.6	233	1.5
18–23	10,300	13.0	9,331	90.6	846	8.2	123	1.2
24–36	10,373	13.1	9,433	90.9	825	8.0	115	1.1
>36	3,941	5.0	3,512	89.1	349	8.9	80	2.0
Maternal age at second birth								
<15 years	56	0.1	51	91.1	4	7.1	1	1.8
15–17 years	13,181	16.7	11,432	86.7	1,447	11.0	311	2.4
18–19 years	65,844	83.3	58,874	89.4	6,000	9.1	970	1.5
Maternal age at first live birth								
< 15 years	2,986	3.8	2,641	88.5	295	9.9	50	1.7
15–17 years	50,154	63.4	44,949	89.6	4,481	8.9	724	1.4
18–19 years	25,941	32.8	22,758	87.7	2,675	10.3	508	2.0
Race/ethnicity								
Non-Hispanic White	25,271	32.0	22,548	89.2	2,353	9.3	370	1.5
Non-Hispanic Black	16,035	20.3	13,599	84.8	2,004	12.5	432	2.7
Hispanic	35,610	45.0	32,260	90.6	2,901	8.2	449	1.3
Other[c]	1,707	2.2	1,529	89.6	152	8.9	26	1.5
Missing	458	0.6	412	90.0	41	9.0	5	1.1
Marital status at second birth								
Married	16,637	21.0	15,002	90.2	1,451	8.7	184	1.1
Unmarried	62,444	79.0	55,346	88.6	6,000	9.6	1,098	1.8

Maternal risk factor	Gestational age of second birth (weeks)							
	Overall		>37		32–36		<32	
	n	%[a]	n	%[b]	n	%[b]	n	%[b]
Previous preterm birth								
Yes	2,082	2.6	1,283	61.6	633	30.4	166	8.0
No	76,601	96.9	68,741	89.7	6,758	8.8	1,102	1.4
Missing	398	0.5	324	81.4	60	15.1	14	3.5
Prenatal care utilization								
Inadequate	11,136	14.1	10,207	91.7	886	8.0	43	0.4
Intermediate	21,741	27.5	19,737	90.8	1,760	8.1	244	1.1
Adequate	19,753	25.0	18,879	95.6	766	3.9	108	0.6
Adequate plus	17,535	22.2	14,245	81.2	2,789	15.9	501	2.9
Missing	8,916	11.3	7,280	81.7	1,250	14.0	386	4.3
Maternal smoking								
Current non-smoker	56,373	71.3	50,404	89.4	5,095	9.0	874	1.6
Quit while pregnant	1,018	1.3	894	87.8	97	9.5	27	2.7
Current smoker	9,244	11.7	8,137	88.0	946	10.2	161	1.7
Missing	12,446	15.7	10,913	87.7	1,313	10.6	220	1.8
Total			70,348	89.0	7,451	9.4	1,282	1.6

[a] Totals are column percentages and may not add up to 100 due to rounding

[b] Totals are row percentages, and may not add up to 100 due to rounding

[c] Other than non-Hispanic white, non-Hispanic white or Hispanic

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Table 2

Unadjusted and adjusted odds ratios for the association between selected risk factors with preterm or very preterm birth (gestational age 32–37 and <32 weeks, respectively) compared with gestational ages of >37 weeks

Gestational age of second birth (weeks)	Unadjusted						Adjusted[b]					
	32–36			<32			32–36			<32		
Maternal risk factor	OR	95 % CI	p	OR	95 % CI	p	aOR	95 % CI	p	aOR	95 % CI	p
IPI												
<3	1.97	1.77–2.18	<.001	2.77	2.18–3.52	<001	1.89	1.70–2.10	<001	2.52	1.98–3.22	<001
3–5	1.39	1.27–1.52	<.001	1.84	1.48–2.28	<001	1.33	1.22–1.47	<001	1.68	1.35–2.10	<001
6–11	1.15	1.06–1.25	.001	1.28	1.04–1.57	.02	1.11	1.02–1.21	.02	1.20	0.97–1.50	.10
12–17	1.05	0.96–1.15	.26	1.24	1.00–1.55	.05	1.03	0.94–1.13	.53	1.20	0.96–1.50	.11
18–23	Ref			Ref			Ref			Ref		
24–36	0.97	0.87–1.07	.48	0.93	0.72–1.19	.55	0.95	0.85–1.05	.28	0.90	0.70–1.16	.41
> 36	1.10	0.96–1.25	.17	1.73	1.30–2.30	<001	1.04	0.91–1.19	.55	1.62	1.22–2.17	.001
Maternal age												
Second birth	0.90	0.87–0.92	<.001	0.78	0.74–0.83	<001	0.92	0.89–0.94	<001	0.81	0.76–0.86	<001
First birth	1.07	1.04–1.09	<.001	1.14	1.09–1.20	<001	N/A			N/A		
Race/ethnicity												
White	Ref			Ref			Ref			Ref		
Black	1.41	1.33–1.50	<.001	1.94	1.68–2.23	<001	1.47	1.37–1.60	<001	1.90	1.60–2.20	<001
Hispanic	0.86	0.81–0.91	<.001	0.85	0.74–0.97	.02	0.98	0.91–1.04	.44	0.95	0.82–1.12	.56
Other[a]	0.95	0.80–1.13	.58	1.04	0.70–1.55	.86	1.08	0.91–1.29	.39	1.23	0.82–1.84	.33
Missing	0.95	0.69–1.32	0.77	0.74	0.30–1.80	0.51	1.00	0.72–1.40	.99	0.72	0.29–1.77	.48
Marital status at second birth												
Married	Ref			Ref			Ref			Ref		
Unmarried	1.12	1.06–1.19	<.001	1.62	1.38–1.89	<001	0.99	0.93–1.06	.84	1.28	1.08–1.51	.004
Previous preterm birth												
Yes	5.02	4.55–5.54	<.001	8.08	6.80–9.60	<001	4.55	4.10–5.04	<001	7.32	6.11–8.76	<001
No	Ref			Ref			Ref			Ref		
Missing	1.88	1.43–2.48	<.001	2.70	1.57–4.62	<001	1.25	0.94–1.66	0.13	1.14	0.66–1.98	0.64
Prenatal care utilization												

Gestational age of second birth (weeks)	Unadjusted						Adjusted[b]					
	32–36			<32			32–36			<32		
Maternal risk factor	OR	95 % CI	p	OR	95 % CI	p	aOR	95 % CI	p	aOR	95 % CI	p
Inadequate	2.14	1.94–2.36	<.001	0.74	0.52–1.05	.09	1.92	1.73–2.12	<001	0.60	0.42–0.86	.005
Intermediate	2.20	2.01–2.40	<.001	2.16	1.72–2.71	<001	2.05	1.88–2.24	<001	1.90	1.51–2.39	<001
Adequate	Ref			Ref			Ref			Ref		
Adequate?	4.83	4.44–5.24	<.001	6.15	4.99–7.58	<001	4.68	4.31–5.09	<001	5.83	4.73–7.20	<001
Missing	4.23	3.85–4.65	<.001	9.30	7.48–11.49	<001	3.81	3.46–4.19	<001	7.80	6.27–9.71	<001
Smoker												
Current non-smoker	Ref			Ref			Ref			Ref		
Quit	1.07	0.87–1.33	.51	1.74	1.18–2.57	.005	1.08	0.87–1.34	.50	1.80	1.20–2.67	.004
Current	1.15	1.07–1.24	<.001	1.14	0.96–1.35	.13	1.12	1.03–1.22	.007	1.15	0.95–1.39	.14
Missing	1.20	1.12–1.30	<.001	1.16	1.00–1.35	0.05	1.06	0.99–1.14	.08	0.89	0.76–1.04	.15

[a]Other than non-Hispanic white, non-Hispanic white or Hispanic

[b]Multivariablemodel includes all variables in the table (age at second birth, race/ethnicity, marital status, previous preterm, prenatal care use, smoking)

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