Prenatal Care and Subsequent Birth Intervals

CONTEXT: *Prenatal care generally includes contraceptive and health education that may help women to control their subsequent fertility. However, research has not examined whether receipt of prenatal care is associated with subsequent birthspacing.*

METHODS: *Longitudinally linked birth records from 113,662 New Jersey women who had had a first birth in 1996–2000 were used to examine associations between the timing and adequacy of prenatal care prior to a woman's first birth and the timing of her second birth. Multinomial logistic regression analyses adjusted for social and demographic characteristics, hospital and year of birth.*

RESULTS: *Most women (85%) had initiated prenatal care during the first trimester. Women who had not obtained prenatal care until the second or third trimester, or at all, were more likely than those who had had first-trimester care to have a second child within 18 months, rather than in 18–59 months (odds ratios, 1.2–1.6). Similarly, women whose care had been inadequate were more likely than those who had had adequate care to have a short subsequent birth interval (1.2). The associations were robust to alternative measures of prenatal care and birth intervals, and were strongest for mothers with less than 16 years of education.*

CONCLUSIONS: *Providers should capitalize on their limited encounters with mothers who initiate prenatal care late or use it sporadically to ensure that these women receive information about family planning.*

Perspectives on Sexual and Reproductive Health, 2012, 44(1):13–21, doi: 10.1363/4401312

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The proportion of U.S. births that were to women who had had a birth in the previous two years increased from 11% to 18% between 1995 and 2002.[1] The reasons for this dramatic increase have not, to our knowledge, been explored. However, the trend may be cause for concern. A meta-analysis published in 2006 found that very short and very long interpregnancy intervals (the time between a birth and the mother's subsequent conception) are associated with adverse perinatal outcomes, including preterm birth, low birth weight and small size for gestational age;[2] these, in turn, are associated with a number of adverse child health and developmental conditions.[3] A 2011 study found that interpregnancy intervals of less than 12 months are strongly associated with the second child's having autism, and that the association is not mediated by low birth weight or preterm birth, suggesting that other causal pathways are involved.[4] The proposed mechanisms by which short interpregnancy intervals lead to adverse infant outcomes generally involve maternal nutritional deficiencies, particularly folate depletion, but are not well understood; hypothesized mechanisms relating long birth intervals to adverse maternal and child health outcomes are even less well developed.*[2]

Prenatal care is one of the most frequently used health services in the United States.[5,6] Standard prenatal care involves a series of visits during which providers educate women about pregnancy, monitor medical conditions (e.g., high blood pressure), test for gestational health problems (e.g., gestational diabetes) and refer expectant mothers to relevant services, such as nutritional programs and family planning resources.[7] For decades, the standard recommendation has been for prenatal care to begin as early as possible during pregnancy or, ideally, prior to conception.[8] Owing largely to expansions of Medicaid coverage for pregnant women in the late 1980s and early 1990s, prenatal care has become nearly universal in the United States; some 92–96% of women who gave birth in 2006 received at least some prenatal care.†[9] However, the timing and adequacy of that care vary. For example, 17–32% of U.S. births in 2006 were to women who had initiated care after the first trimester,[9] and 25% of births in 2002 were to women who had had less than adequate prenatal care, as defined by the Adequacy of Prenatal Care Utilization Index[10] (which takes into consideration both the timing of initiation of care and the number of visits). An explicit goal of the Healthy People 2020 plan is to increase the proportion of pregnant women who receive early and adequate prenatal care by 10% from its 2007 level.[11]

*The patchwork literature on the outcomes associated with birth intervals uses inconsistent definitions of both long and short intervals.

†The ranges for 2006 reflect differences in the wording of questions on the two versions (1989 and 2003) of the U.S. Standard Certificate of Live Birth that were used at the time.

Most research on the effectiveness of prenatal care has focused on infant health outcomes (typically birth weight or mortality) and has found very modest or no effects.[12,13] Some recent studies have taken a broader view of the potential impact of prenatal care, recognizing that the benefits of providing pregnant women with health information and counseling (typical components of prenatal care) may last long after the child is born. Indeed, the broad goal of contemporary prenatal care is to promote the health of the mother, child and family through the pregnancy, the delivery and the child's development.[8] Some evidence suggests that prenatal services improve women's postpartum health behaviors. For example, one randomized controlled study found that prenatal education and counseling about breast-feeding increase rates of the practice among low-income urban black women,[14] and a study that used econometric techniques to address potential bias from omitted variables found evidence strongly suggesting that first-trimester prenatal care reduces the prevalence of postpartum maternal smoking, as well as some evidence that it may increase that of breast-feeding.[15]

To our knowledge, the role of standard prenatal care in shaping future reproductive behaviors has not been studied. Because such care includes information about family planning, it may affect subsequent birthspacing through fertility control. In a study that used 2004–2005 Prenatal Risk Assessment Monitoring System (PRAMS) data from Florida, 80% of mothers reported that during the prenatal period, a health care worker talked to them about postpartum birth control use.[16] This figure is identical to an aggregate estimate based on 2006 data from 24 PRAMS sites.[17] In principle, prenatal counseling about family planning could help women prevent unwanted pregnancy. Data from the Guttmacher Institute suggest that public funding of family planning programs in the United States is effective in preventing unintended pregnancy[18] and abortion;[19] however, the evidence that clinical interventions prevent unintended pregnancy and improve contraceptive use is mixed, although the literature is fraught with methodological issues, such as small sample sizes, high attrition and weak interventions.[20,21]

In addition to any impact prenatal care may have on postnatal contraceptive use, it could affect subsequent birth intervals though other means, such as by encouraging breast-feeding (which is associated with reduced fecundity).[22] It may also increase fertility control by providing health education, which can empower women and help them choose contraceptive methods that are consistent with their lifestyle preferences and values, as well as lead to greater contraceptive efficacy and perhaps to decisions to terminate unplanned pregnancies. In developing countries, fertility is inversely related to women's educational attainment, women's reproductive behavior is strongly influenced by societal levels of economic development and gender inequality, and the impact of education on fertility depends on women's autonomy.[23,24] Interest in informal programs designed to educate women in developing countries about family planning and empower them to control their fertility has been substantial—particularly since the International Conference on Population and Development, in Cairo (1994), and the fourth World Conference on Women, in Beijing (1995)—and evidence indicates that such programs affect reproductive behavior.[24] While population-based research on the effects of reproductive health education on fertility in developed countries has been scant, such education provided as part of prenatal care may empower women to control their fertility even in these contexts. That is, underlying issues of population and development in the developing world, such as women's education and autonomy, may be relevant—at least to some extent—in developed countries.

Prenatal care may also facilitate fertility control by connecting mothers to medical and social service systems, some for the first time. Children whose mothers had early or adequate prenatal care are more likely than those whose mothers had inadequate or late care to have the recommended numbers of well-child medical visits and immunizations, after income and other measures of socioeconomic status are taken into account.[25,26] A study using econometric techniques to address potential bias due to omitted variables had similar findings regarding well-child visits.[15] Connection to the health care system may provide access to, and encourage the use of, family planning services.

Evidence that prenatal care affects subsequent birthspacing would call for a reexamination of the role and content of such care, especially if the findings shed light on the underlying pathways. Given that half of all births in the United States are unintended,[27] the potential impact of prenatal care on subsequent fertility is substantial. In this study, we take the first steps in investigating this issue by establishing whether an association exists between exposure to prenatal care and subsequent birth intervals, and by assessing whether differences among groups of mothers in the magnitude of this association are consistent with our conceptualization of how prenatal care might affect fertility. We hypothesized that increased exposure to prenatal care is associated with increased fertility control and a reduced likelihood of short subsequent birth intervals; that the associations between prenatal care and long birth intervals are much weaker than those for short birth intervals, since family planning messages conveyed during prenatal care should affect behavior more during the postpartum period than in the long term; and that the associations between prenatal care and birth intervals are strongest for women with low educational attainment, who stand to gain the most from prenatal health information.

METHODS

Sample

We linked electronic birth certificate files from New Jersey across births to the same mother. The linked file we used included records for approximately one million live births that occurred from 1996 to 2006. During this period, New Jersey used the 1989 version of the U.S. Standard Certificate of Live Birth; like most other states, it had

not adopted the revised 2003 form by the end of 2006. However, during data collection, the standard birth certificate fields were augmented with additional variables of interest to the state.

The birth certificate files contained identifying information for each mother, as well as the date of her last live birth, which allowed us to match in-state births to the same mother during the observation period. For 76% of the birth certificates indicating that the mother had had a prior live birth on or after January 1, 1996, we were able to find the records for the previous birth; the other 24% of births were to mothers who had given birth in another state or whose records did not match to the previous birth for other reasons (which cannot be determined from this file). As might be expected, the match rate was highest for women who were born in New Jersey (82%) and much lower for those who were foreign-born (63%).* The linkage process is described in more detail elsewhere.[28] The electronic birth certificate files contained data on the timing and use of prenatal care, the date and hospital of birth, demographic and other characteristics that are routinely available in natality files, and Medicaid coverage for the birth.

We restricted our analysis to women who had a first birth between 1996 and 2000. Of these 208,142 women, we identified 130,919 who had at least one other birth in New Jersey by 2006. After we removed cases with missing records on intermediate births, the sample was reduced to 126,360 mothers. We further restricted the sample to the 125,140 mothers whose first and second births were both singletons. We excluded mothers whose listed birth intervals were shorter than the gestational age of their second child (231 women); we also excluded, in turn, mothers who were missing data on Medicaid status (4,407), month of prenatal care initiation (4,059), or demographic characteristics, number of prenatal visits or gestational age (2,781). Thus, our final sample comprised 113,662 mothers.

While the proportion of women with missing data on any one measure was small (4% or less), the pattern of sample loss due to missing data was not random; missing data were especially common among mothers who had short or long birth intervals, women who were teenagers at the time of their first delivery, black women and women who were unmarried at the time of the first birth.

TABLE 1. Percentage distribution of New Jersey women who had a first birth in 1996–2000 and a subsequent birth by 2006, by selected characteristics, according to timing of first prenatal care visit

Characteristic	All (N=113,662)	1–3 months (N=96,914)	4–6 months (N=13,508)	7–9 months (N=2,840)	No care (N=400)
Age* **					
≤19	14.0	10.0	35.5	39.5	55.5
20–34	79.4	82.7	61.4	57.9	42.5
≥35	6.6	7.3	3.0	2.7	2.0
Race/ethnicity* **					
White	62.7	67.5	36.0	32.7	31.3
Black	11.9	9.6	24.4	26.5	40.3
Hispanic	16.7	14.4	30.3	30.7	23.5
Other	8.6	8.5	9.2	9.9	4.8
Nativity* **					
U.S.-born	76.1	78.0	65.9	62.3	79.0
Foreign-born	23.9	22.0	34.1	37.7	21.0
Yrs. of education* **					
<12	13.2	9.7	32.6	36.4	48.3
12–15	47.5	47.1	50.0	47.0	44.3
≥16	39.3	43.2	17.4	16.6	7.5
Marital status* **					
Married/had father information	71.9	77.5	40.5	38.2	14.8
Unmarried/had father information	22.2	18.5	44.7	40.5	44.5
No father information	5.9	4.0	14.8	21.3	40.8
Medicaid-covered birth* **					
Yes	20.9	16.3	47.3	48.6	29.3
No	79.1	83.7	52.7	51.4	70.7
Total	100.0	100.0	100.0	100.0	100.0

***p<.001 from chi-square tests of equal proportions. *Note:* Percentages may not total 100.0 because of rounding.

Measures

Our primary outcome measure was length of time between the mother's first and second births, categorized as less than 18 months, 18–59 months, or 60 or more months. Although examining interpregnancy intervals would have better captured reproductive behavior subsequent to prenatal care, we focused on birth intervals because we did not have data on second pregnancies that did not result in live births (i.e., those that ended in miscarriages or induced abortions). However, in supplementary models, we did consider interpregnancy intervals, which we calculated as the birth interval minus the second child's gestational age; this frequently used formula[2,4] is equivalent to the interval from the date of birth of the first child to the estimated date of conception of the second. In our sample of live births, the average difference between the woman's birth interval and her interpregnancy interval (i.e., the gestational age of the second child) was 8.96 months. Because the cutoffs used in prior studies for long and short birth and interpregnancy intervals have varied, we assessed the sensitivity of our estimates to alternative interval cutoffs.

Our main measure of exposure to prenatal care was a categorical variable characterizing whether the mother's first prenatal visit took place during the first three months of the pregnancy corresponding to her first birth, during months 4–6, during months 7–9 or not at all. In the coding instructions for the New Jersey electronic birth certificate, prenatal care visits were defined as visits with a health professional specifically related to the current pregnancy, including visits for physical examination, history, counseling or treatment. We also assessed adequacy of prenatal care, as measured by the revised Graduated Index of

*Reported match rates are based on the proportion of second births in New Jersey that match first births in the state, and not the proportion of first births that match second births. The match rate is likely to be much higher for immigrants when the sample is restricted to first births that occurred in New Jersey, as it is in our analyses.

Prenatal Care Utilization (R-GINDEX), which takes into consideration both the month of prenatal care initiation and the disparity between the number of prenatal care visits and the number of visits recommended by the American Congress of Obstetricians and Gynecologists, given the infant's gestational age at delivery.[29] The R-GINDEX categorizes care as inadequate, intermediate, adequate, intensive (a level generally indicative of a high-risk pregnancy), no care or missing.

Control variables included in our analyses—all of which were measured at the time of the first birth—included the mother's age (categorized as younger than 20 years, 20–34, or 35 or older), race and ethnicity (white, black, Hispanic or other), nativity (foreign-born or U.S.-born) and years of education (fewer than 12, 12–15, or 16 or more). We also included a variable that encompassed the mother's marital status and whether the birth record contained information about the father; women were classified as married with father information, unmarried with father information or lacking father information (whether married or unmarried). Another measure indicated whether the birth was covered by Medicaid (a proxy for poverty). Finally, to control for unobserved factors that may vary by hospital and over time, we included indicators for hospital and year of first birth.

TABLE 2. Percentage distribution of New Jersey women who had a first birth in 1996–2000 and a subsequent birth by 2006, by birth interval, according to selected characteristics

Characteristic	<18 months (N=12,437)	18–59 months (N=84,609)	≥60 months (N=16,616)	Total (N=113,662)
All ***	**10.9**	**74.4**	**14.6**	**100.0**
Timing of first prenatal care visit***				
1–3 months	10.4	76.1	13.5	100.0
4–6 months	13.9	65.1	21.1	100.0
7–9 months	14.9	65.1	20.0	100.0
No prenatal care	17.5	57.3	25.3	100.0
Adequacy of prenatal care***				
Intensive	10.2	76.0	13.8	100.0
Adequate	10.3	76.4	13.3	100.0
Intermediate	10.8	74.1	15.1	100.0
Inadequate	14.0	68.1	17.9	100.0
No prenatal care	16.7	57.9	25.4	100.0
Missing	11.3	75.3	13.4	100.0
Age***				
≤19	14.2	59.9	25.9	100.0
20–34	10.2	76.4	13.4	100.0
≥35	12.9	81.2	5.9	100.0
Race/ethnicity***				
White	9.9	79.3	10.8	100.0
Black	13.8	62.2	24.1	100.0
Hispanic	13.0	65.2	21.8	100.0
Other	10.4	74.0	15.5	100.0
Nativity***				
U.S.-born	10.6	75.8	13.6	100.0
Foreign-born	12.0	70.1	17.8	100.0
Yrs. of education***				
<12	14.9	61.6	23.5	100.0
12–15	11.3	71.2	17.5	100.0
≥16	9.2	82.7	8.1	100.0
Marital status***				
Married/had father information	10.4	79.8	9.9	100.0
Unmarried/had father information	12.5	61.5	26.0	100.0
No father information	12.2	58.3	29.5	100.0
Medicaid-covered birth***				
Yes	14.1	61.1	24.8	100.0
No	10.1	78.0	11.9	100.0

***p<.001 from chi-square tests of equal proportions. *Note:* Percentages may not total 100.0 because of rounding.

Analyses

First, we present sample characteristics by trimester of prenatal care initiation, and subsequent birth intervals by timing of prenatal care initiation, adequacy of prenatal care and maternal characteristics. In these descriptive analyses, we report results from chi-square tests of equal proportions to identify significant differences across prenatal care groups. Next, we present a series of multivariate analyses that used multinomial logistic regression with robust standard errors to account for clustering at the hospital level. For each model, we report results from tests of statistical significance for the multinomial regression estimates, as well as McFadden's pseudo-R^2 statistics for model fit.

The multivariate analyses are intended to identify associations between prenatal care during a first pregnancy and the timing of the mother's second birth, after adjustment for other factors that may be associated with both measures. A potential limitation of our approach is that mothers in our sample were not equally exposed to the risk of having a long birth interval. Those who had their first birth in 1996 were observed for 10–11 years, whereas those who had their first birth in 2000 were observed for only 6–7 years. However, the indicator for year of first birth adjusts for unequal exposure. Moreover, most second births in our sample took place within the lower-bound exposure interval of 6–7 years. Specifically, 89% of mothers who were observed for 10–11 years had their second birth within six years.

In addition to estimating multinomial logistic regression models for the full sample, we conducted analyses stratified by maternal education (fewer than 12 years vs. 12 or more); to minimize potential confounding between maternal education and age, these analyses were limited to mothers who were at least 25 years old. Finally, we conducted a set of supplementary analyses to explore the sensitivity and robustness of our findings.

RESULTS

Descriptive Analyses

Eighty-five percent of the mothers had initiated prenatal care in the first trimester of pregnancy, 12% in the second trimester and 3% in the third; fewer than 1% had no care at all. Those who had initiated care in the first trimester were more likely than later initiators to be 20 or older, white, well educated (i.e., to have 16 or more years of education) and married; they were less likely than later initiators to have been born outside of the United States and to have had their births covered by Medicaid (Table 1, page 15).

TABLE 3. Odds ratios from multinomial logistic regression model of associations between timing of first prenatal care visit and length of subsequent birth interval

Characteristic	<18 months	≥60 months
Timing of first visit		
1–3 months (ref)	1.00	1.00
4–6 months	1.19***	1.03
7–9 months	1.26***	0.94
No prenatal care	1.61***	1.15
Age		
≤19	1.14***	1.09*
20–34 (ref)	1.00	1.00
≥35	1.33***	0.58***
Race/ethnicity		
White (ref)	1.00	1.00
Black	1.31***	1.32*
Hispanic	1.11*	1.24***
Other	1.06	1.46***
Nativity		
U.S.-born (ref)	1.00	1.00
Foreign-born	1.08**	1.23***
Yrs. of education		
<12	1.45***	1.36***
12–15	1.26***	1.60***
≥16 (ref)	1.00	1.00
Marital status		
Married/had father information (ref)	1.00	1.00
Unmarried/had father information	0.97	2.44**
No father information	0.86*	2.51***
Medicaid-covered birth		
Yes	1.23***	1.09**
No (ref)	1.00	1.00
McFadden's pseudo-R^2=.05		
df=69		

*p<.05. **p<.01. ***p<.001. *Notes:* Model includes hospital and year indicators with adjusted standard errors to account for clustering by hospital. Reference birth interval is 18–59 months.

TABLE 4. Odds ratios from multinomial logistic regression model of associations between adequacy of prenatal care and length of subsequent birth interval

Characteristic	<18 months	≥60 months
Adequacy of prenatal care		
Intensive	0.97	1.01
Adequate (ref)	1.00	1.00
Intermediate	1.01	0.97
Inadequate	1.23***	0.95
No prenatal care	1.53**	1.13
Missing	1.08	0.94
Age		
≤19	1.15***	1.10*
20–34 (ref)	1.00	1.00
≥35	1.33***	0.58***
Race/ethnicity		
White (ref)	1.00	1.00
Black	1.31***	1.32***
Hispanic	1.12*	1.24***
Other	1.06	1.46***
Nativity		
U.S.-born (ref)	1.00	1.00
Foreign-born	1.09**	1.23***
Yrs. of education		
<12	1.46***	1.36***
12–15	1.26***	1.60***
≥16 (ref)	1.00	1.00
Marital status		
Married/had father information (ref)	1.00	1.00
Unmarried/had father information	0.98	2.45***
No father information	0.87*	2.52***
Medicaid-covered birth		
Yes	1.24***	1.09**
No (ref)	1.00	1.00
McFadden's pseudo-R^2=.05		
df=71		

*p<.05. **p<.01. ***p<.001. *Notes:* Model includes hospital and year indicators with adjusted standard errors to account for clustering by hospital. Reference birth interval is 18–59 months.

Eleven percent of the mothers gave birth to their second child within 18 months of having the first; 74% had their second child 18–59 months after the first and 15% had their second five or more years after the first (Table 2). Timing of prenatal care, adequacy of care, and all social and demographic characteristics were associated with subsequent birth interval. In particular, characteristics associated with a reduced likelihood of short or long birth intervals included having had early prenatal care, having had adequate or intensive prenatal care, being white, being U.S.-born, having 16 or more years of education, being married and not having received Medicaid benefits. Levels of both short and long birth intervals were higher among teenage mothers than among any other age-group; mothers 35 or older were the least likely age-group to have long birth intervals.

Multivariate Analyses

Consistent with the bivariate results, timing of prenatal care initiation was associated with subsequent birth interval in multivariate analyses (Table 3). In particular, initiation of care after the first trimester was strongly associated with a short birth interval. The odds of having a second child within 18 months, rather than in 18–59 months, were raised by 19% if the mother had initiated prenatal care during her second trimester as opposed to her first (odds ratio, 1.2). The odds of a short birth interval were elevated further among mothers who had initiated care during the third trimester (1.3), and further yet among those who had not obtained any prenatal care (1.6). In contrast, no association emerged between timing of prenatal care and long birth intervals.

The associations between control variables and birth intervals also were consistent with those of the bivariate analysis. Maternal age younger than 20 was positively associated with both short and long birth intervals (odds ratios, 1.1 for each). Women aged 35 or older were more likely than those aged 20–34 to have a short birth interval, rather than an interval of 18–59 months (1.3), but less likely to have a long birth interval (0.6), perhaps reflecting decreased fecundity at advanced maternal age. Black and Hispanic women were more likely than white women to have birth intervals other than 18–59 months

TABLE 5. Odds ratios from multinomial logistic regression models of associations between timing of first prenatal care visit and length of subsequent birth interval among mothers aged 25 or older, by maternal education

Characteristic	<16 yrs. of education (N=33,653)		≥16 yrs. of education (N=42,418)	
	Birth interval <18 months	Birth interval ≥60 months	Birth interval <18 months	Birth interval ≥60 months
Timing of first prenatal visit				
1–3 months (ref)	1.00	1.00	1.00	1.00
4–6 months	1.23**	1.01	1.07	1.01
7–9 months	1.28	1.02	1.35	1.05
No prenatal care	1.75	1.46	3.87	5.24
Age				
25–34 (ref)	1.00	1.00	1.00	1.00
≥35	2.47***	1.90***	1.95***	1.35***
Race/ethnicity				
White (ref)	1.00	1.00	1.00	1.00
Black	0.78**	0.64***	0.73**	0.56***
Hispanic	0.78**	0.69***	0.87	0.69***
Other	0.82*	0.68***	0.56***	0.61***
Nativity				
U.S.-born (ref)	1.00	1.00	1.00	1.00
Foreign-born	1.12	0.95	0.71***	0.65***
Marital status				
Married/ had father information (ref)	1.00	1.00	1.00	1.00
Unmarried/ had father information	0.66***	0.51***	0.34***	0.36***
No father information	0.36***	0.40***	0.26***	0.18***
Medicaid-covered birth				
Yes	1.07	0.88*	1.28	0.95
No (ref)	1.00	1.00	1.00	1.00
McFadden's pseudo-R^2	.03		.03	
df	70		68	

*p<.05. **p<.01. ***p<.001. *Notes:* Models include hospital and year indicators with adjusted standard errors to account for clustering by hospital. Reference birth interval is 18–59 months.

(1.1–1.3). Women who were immigrants or had fewer than 16 years of education also had elevated odds of both short and long birth intervals (1.1–1.6). Among women for whom information about the father of their first child was available, unmarried mothers were as likely as married ones to have short birth intervals, but much more likely than married mothers to have long intervals (2.4). Lack of father information for the first birth was negatively associated with short birth intervals (0.9), but positively associated with long birth intervals (2.5). Having had a birth covered by Medicaid was positively associated with both short and long birth intervals (1.1–1.2).

In analyses that considered the adequacy of prenatal care, the odds of having a second birth within 18 months (rather than in 18–59 months) were 23% greater if a woman had had inadequate rather than adequate care (odds ratio, 1.2—Table 4, page 17). The odds ratios for other measures were virtually identical to those in the analyses using timing of care.

Results of analyses that stratified women aged 25 or older by their educational attainment were generally consistent with our predictions. Initiation of care in the second (rather than first) trimester was positively associated with short birth intervals among mothers with fewer than 16 years of education (odds ratio, 1.2), but not among better-educated women (Table 5). The odds ratios for associations between third-trimester prenatal care and subsequent birth intervals were similar for the two education groups, although neither was statistically significant. The associations between having had no prenatal care and subsequent birth intervals were imprecisely estimated because of very small sample sizes, particularly for the more highly educated group.

Sensitivity and Supplemental Analyses

We assessed the sensitivity of our results regarding the associations between the timing of women's first prenatal care visit and short subsequent birth intervals to three alternative approaches: treating birth interval as a binary outcome; using interpregnancy intervals rather than birth intervals as the outcome; and using alternative cutoffs for both birth intervals and interpregnancy intervals. First, we found that the odds ratios from logistic regression models for the associations between the timing of prenatal care initiation and either a birth interval of fewer than 18 months or an interpregnancy interval of fewer than nine months (Table 6) were almost identical to the ratios from the multinomial regression models for a birth interval of fewer than 18 months (Table 3). The similarities between the estimates for birth intervals less than 18 months and interpregnancy intervals less than nine months are not surprising, since (as discussed earlier) a birth interval of 18 months is almost the same as an interpregnancy interval of nine months in a sample of live births. Likewise, the odds ratios for the relationship between timing of prenatal care initiation and birth intervals of fewer than 21 months were almost identical to those for interpregnancy intervals of fewer than 12 months (Table 6). For both outcomes (birth interval and interpregnancy interval), the covariate estimates were largely insensitive to the cutoff used.

In addition, we conducted supplementary analyses corresponding to Table 3 that limited the sample to U.S.-born mothers, that limited the sample to mothers who were at least 25 years old or that stratified the sample by Medicaid status. In all sets of analyses, the results were very similar to those for the full sample. Specifically, initiating prenatal care during the second or third trimester (rather than the first) was positively associated with short birth intervals; it was generally not associated with long birth intervals, except for third-trimester initiation of care among U.S.-born mothers (odds ratio, 0.83).

We further validated the findings by repeating the analyses from Table 3 using the month rather than trimester of prenatal care initiation, and using the Adequacy of Prenatal Care Utilization Index rather than the R-GINDEX. In both cases, the negative association between greater intensity of prenatal care and short birth intervals was replicated. Furthermore, in both instances, a clear dose response was apparent.

We also estimated models corresponding to those in Table 3 that stratified the sample by either maternal age (younger than 20 vs. 20 or older), race and ethnicity, or marital status, all of which were associated with sample loss. The relationship between prenatal care timing and birth intervals among teenagers was very similar to that among adults, and that among married mothers closely resembled that among unmarried ones. The association between timing of prenatal care initiation and subsequent birth intervals was somewhat weaker among blacks than among whites; because levels of missing data were higher among blacks than among whites, this finding suggests that the estimates for the full sample in Table 3 might be inflated. However, the inflation from this source is unlikely to be substantial, as the rate of missing data was low even among blacks, who accounted for less than 15% of the total sample.

Finally, we estimated models corresponding to those in Table 3 that controlled for county of residence, rather than for hospital of birth, and adjusted the standard errors for clustering at the county level; the results were insensitive to this alternative specification.

TABLE 6. Odds ratios from logistic regression models of associations between timing of first prenatal care visit and length of birth and interpregnancy intervals

Characteristic	Birth interval		Interpregnancy interval	
	<18 months (N=113,649)	<21 months (N=113,656)	<9 months (N=113,649)	<12 months (N=113,656)
Timing of first prenatal visit				
1–3 months (ref)	1.00	1.00	1.00	1.00
4–6 months	1.19***	1.17***	1.19***	1.17***
7–9 months	1.28***	1.21**	1.29***	1.20**
No prenatal care	1.56***	1.58***	1.48**	1.52***
Age				
≤19	1.11**	1.04	1.11**	1.04
20–34 (ref)	1.00	1.00	1.00	1.00
≥35	1.39***	1.44***	1.38***	1.42***
Race/ethnicity				
White (ref)	1.00	1.00	1.00	1.00
Black	1.25***	1.19***	1.23***	1.17***
Hispanic	1.07	1.03	1.08	1.01
Other	1.01	0.93	0.98	0.91
Nativity				
U.S.-born (ref)	1.00	1.00	1.00	1.00
Foreign-born	1.05	1.04	1.05	1.05
Yrs. of education				
<12	1.43***	1.29***	1.43***	1.29***
12–15	1.20***	1.08*	1.19***	1.07*
≥16 (ref)	1.00	1.00	1.00	1.00
Marital status				
Married/ had father information (ref)	1.00	1.00	1.00	1.00
Unmarried/ had father information	0.81***	0.73***	0.80***	0.73***
No father information	0.69***	0.64***	0.68***	0.64***
Medicaid-covered birth				
Yes	1.20***	1.17***	1.21***	1.17***
No (ref)	1.00	1.00	1.00	1.00
McFadden's pseudo-R^2	*.01*	*.01*	*.01*	*.01*
df	*17*	*18*	*17*	*18*

*p<.05. **p<.01. ***p<.001. *Notes:* Models include hospital and year indicators with adjusted standard errors to account for clustering by hospital. The reference category in each model consists of all birth or interpregnancy intervals that occurred after the relevant cutoff. Interpregnancy interval is calculated as the birth interval minus the gestational age of the second child. Sample sizes are slightly smaller than the full analytic sample because observations were lost as a result of perfect collinearity.

DISCUSSION

Prior research on maternal and infant health has generally failed to find that prenatal care has substantial effects on important neonatal outcomes, such as birth weight and gestational age. This may be because, for many women, the intervention is "too little, too late" to affect the outcome of the pregnancy. However, recent research provides evidence that prenatal care has positive effects on subsequent health behaviors, including postpartum cigarette smoking, use of well-child care and possibly breastfeeding.[15] Such behavioral changes may improve maternal postpartum health and confer an array of long-term protective effects. In this vein, we examined whether use of prenatal care before a first birth is associated with women's ability to time their second births more consistently with public health guidelines—that is, whether prenatal care is related to optimal subsequent birthspacing. While our data contain no direct measures of family planning or fertility-related behavior, short birth intervals are de facto evidence of lack of fertility control.

Our findings provide strong evidence that earlier and more intensive exposure to prenatal care during a first pregnancy is associated with more optimal spacing and thus, most likely, with better fertility control. Not only are odds ratios for the associations between prenatal care and subsequent short birth intervals large, as well as robust to numerous model specifications, but the associations appear to be dose-dependent. As hypothesized, we also found that the association is greatest among women with low educational attainment.

Despite strong interest among family planning scholars and practitioners in informal programs designed to educate and empower women in developing countries regarding fertility control, this approach has garnered little attention in the United States. Our findings suggest that the possible benefits of discussing family planning during prenatal care visits—which may be among the first encounters that many U.S. women have with the preventive health care system—should be further investigated, as the potential impact on public health is large. Although most mothers report having received family planning counseling from their prenatal care providers, we are not aware of any published guidelines specifying the content of this counseling, or of any data on whether birthspacing is discussed during standard prenatal care. Future research should explore the content of this counseling and its associations with birthspacing and other reproductive outcomes. More generally, our findings also add to a growing body of evidence that prenatal care is associated with a variety of desirable outcomes not directly linked to the targeted pregnancy.

Limitations

Our study has certain limitations. First, we studied births that occurred during a relatively brief time period and in only one state; moreover, the linked birth records excluded women who had moved out of state between their first and second births. However, New Jersey's population, more than that of nearly any other state, reflects the composition and diversity of the U.S. population.[30] In addition, because our sample included all pairs of first and second births in the state during a recent observation window, nonresponse bias should be minimal. These attributes make us confident that our results may be generalizable beyond this sample.

Second, although our analyses controlled for many possible confounding factors, including hospital of birth and Medicaid status, the strong associations we found between prenatal care and short birth intervals may reflect omitted characteristics that are associated with both prenatal care use and birthspacing. Therefore, we cannot assume that the associations we found reflect causal relationships. However, our findings suggest that late initiation of prenatal care before a first birth is a risk factor for having a second birth too soon.

Third, with our data we were not able to explore the potential pathways between prenatal care and subsequent fertility outlined earlier, and had only limited ability to investigate associations between prenatal care and interpregnancy intervals. Both of these areas of inquiry represent potentially important directions for future research and for shaping the content of prenatal family planning interventions.

Conclusion

The findings from this study are particularly timely because several states, including New Jersey, have reduced or eliminated state funding for family planning, and proposals have been made to do the same at the federal level. The dwindling of public family planning resources makes it all the more imperative to learn about and exploit the potential benefits of prenatal care, which is used by almost all pregnant women, to make up some of the gap. While this strategy cannot prevent unwanted first births, it nevertheless has great promise, given that an estimated 75% of unwanted births occur among women who have already had at least one live birth.[31] Providers should capitalize on their limited encounters with women who initiate prenatal care late, or use it sporadically, to ensure that these women receive information about family planning.

REFERENCES

1. Centers for Disease Control and Prevention, Data 2010: the Healthy People 2010 database, 2011, <http://wonder.cdc.gov/data2010/focus.htm>, accessed Jan. 20, 2011.

2. Conde-Agudelo A, Rosas-Bermúdez A and Kafury-Goeta AC, Birth spacing and risk of adverse perinatal outcomes: a meta-analysis, *Journal of the American Medical Association,* 2006, 295(15):1809–1823.

3. Reichman NE, Low birth weight and school readiness, *Future of Children,* 2005, 15(1):91–116.

4. Cheslack-Postava K, Liu K and Bearman PS, Closely spaced pregnancies are associated with increased odds of autism in California sibling births, *Pediatrics,* 2011, 127(2):246–253.

5. Kogan MD et al., The changing pattern of prenatal care utilization in the United States, 1981–1995, using different prenatal care indices, *Journal of the American Medical Association,* 1998, 279(20):1623–1628.

6. Schappert SM, Ambulatory care visits to physician offices, hospital outpatient departments, and emergency departments: United States, 1996, *Vital and Health Statistics,* 1998, Series 13, No. 134.

7. March of Dimes, Prenatal care, no date, <http://www.marchofdimes.com/pnhec/159_513.asp>, accessed Jan. 21, 2011.

8. U.S. Department of Health and Human Services (DHHS), *Caring for Our Future: The Content of Prenatal Care,* Washington, DC: DHHS, 1989.

9. Martin JA et al., Births: final data for 2006, *National Vital Statistics Reports,* 2009, Vol. 57, No. 7.

10. March of Dimes, Prenatal care: distribution of prenatal care adequacy categories: US, 2002, no date, <http://www.marchofdimes.com/peristats/level1.aspx?dv=ms&reg=99&top=5&stop=33&lev=1&slev=1&obj=3>, accessed Jan. 7, 2011.

11. DHHS, Healthy People 2020 summary of objectives, no date, <http://healthypeople.gov/2020/topicsobjectives2020/pdfs/MaternalChildHealth.pdf>, accessed Dec. 22, 2011.

12. Reichman NE et al., Infant health production functions: What a difference the data make, *Health Economics,* 2009, 18(7):761–782.

13. Reichman NE and Teitler JO, Timing of enhanced prenatal care and birth outcomes in New Jersey's HealthStart program, *Maternal and Child Health Journal,* 2005, 9(2):151–158.

14. Kistin N et al., Breast-feeding rates among black urban low-income women: effect of prenatal education, *Pediatrics,* 1990, 86(5):741–746.

15. Reichman NE et al., Effects of prenatal care on maternal postpartum behaviors, *Review of Economics of the Household,* 2010, 8(2):171–197.

16. Hernandez LE et al., Is effective contraceptive use conceived prenatally in Florida? The association between prenatal contraceptive counseling and postpartum contraceptive use, *Maternal and Child Health Journal,* 2012 (forthcoming).

17. D'Angelo DV, Centers for Disease Control and Prevention, Atlanta, personal communication, Mar. 9, 2009.

18. Cleland K et al., Family planning as a cost-saving preventive health service, *New England Journal of Medicine,* 2011, 364(18):e37.

19. Frost JJ, Finer LB and Tapales A, The impact of publicly funded family planning clinic services on unintended pregnancies and government cost savings, *Journal of Health Care for the Poor and Underserved,* 2008, 19(3):778–796.

20. Halpern V et al., Strategies to improve adherence and acceptability of hormonal methods for contraception, *Cochrane Database of Systematic Reviews,* 2011, Issue 4, No. CD004317.

21. Moos MK, Bartholomew NE and Lohr KN, Counseling in the clinical setting to prevent unintended pregnancy: an evidence-based research agenda, *Contraception,* 2003, 67(2):115–132.

22. VanLandingham M, Trussell J and Grummer-Strawn L, Contraceptive and health benefits of breastfeeding: a review of the recent evidence, *International Family Planning Perspectives,* 1991, 17(4):131–136.

23. Jejeebhoy SJ, *Women's Education, Autonomy, and Reproductive Behaviour: Experience from Developing Countries,* New York: Oxford University Press, 1996.

24. Moulton J, *Formal and Nonformal Education and Empowered Behavior: A Review of the Research Literature,* Washington, DC: Academy for Educational Development, 1997.

25. Freed GL et al., Influences on the receipt of well-child visits in the first two years of life, *Pediatrics,* 1999, 103(Suppl. 1):864–869.

26. Kogan MD et al., The association between adequacy of prenatal care utilization and subsequent pediatric care utilization in the United States, *Pediatrics,* 1998, 102(1):25–30.

27. Henshaw SK, Unintended pregnancy in the United States, *Family Planning Perspectives,* 1998, 30(1):24–29 & 46.

28. Denk CE and Kruse LK, Operational assessment of linked files: time for some standards? Paper presented at the Second International Symposium on Successive Pregnancy Outcomes: A Decade of Progress, New Brunswick, NJ, Aug. 19–20, 2005.

29. Alexander GR and Kotelchuck M, Quantifying the adequacy of prenatal care: a comparison of indices, *Public Health Reports,* 1996, 111(5):408–418.

30. House of Representatives, 102nd Congress, *America's Changing Profile: Hearing Before the Subcommittee on Census and Population of the Committee on Post Office and Civil Service, House of Representatives, One Hundred Second Congress, Second Session, May 26, 27; June 23, 24; July 28, 29; September 22, 1992,* Washington, DC: U.S. Government Printing Office, 1994.

31. Finer LB, Guttmacher Institute, New York, personal communication, July 14, 2011.

Acknowledgment

The authors thank Nathan Hutto for valuable research assistance.

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