Birth Spacing and Sibling Outcomes

PRELIMINARY AND INCOMPLETE

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Abstract

This paper investigates the effect of the age difference between siblings (spacing) on educational achievement. We use a sample of women from the 1979 NLSY, matched to reading and math scores for their children from the NLSY79 Children and Young Adults Survey. OLS results suggest that greater spacing is beneficial for older siblings, though only for low socioeconomic-status (SES) families. For high-SES families, greater spacing has no beneficial effect and is associated with lower test scores for younger siblings. However, because we are concerned that spacing may be correlated with unobservable characteristics, we also use an instrumental variables strategy that exploits variation in spacing driven by miscarriages that occur between two live births. The IV results indicate that a one-year increase in spacing increases test scores for low-SES older siblings by about 0.15 standard deviations and spacing less than two years between children decreases test scores by about 0.87 standard deviations. For younger siblings there appears to be no causal impact of spacing on test scores.

I. Introduction

A large body of work in economics and other disciplines has found a relationship between family structure and children's outcomes. For example, children from larger families generally have lower educational attainment, worse employment outcomes, and greater likelihood of engaging in risky behavior (Kessler, 1991; Hanushek, 1992; Steelman, et al., 2002; Deschenes, 2007; Black, Devereux and Salvanes 2010). A more recent literature in economics has considered the effects of birth order and found that later born children have lower educational attainment, receive less parental time investment, and in some cases have worse labor market outcomes (Black, Devereux, and Salvanes, 2005; Price, 2008). There is even evidence that the gender composition of one's siblings affects educational attainment, though results are mixed (Dahl and Moretti, 2008; Conley, 2000; Butcher and Case, 1994; Hauser and Kuo, 1998; Kaestner, 1997).

However, one component of family structure has received much less attention in the economic literature: the age difference between siblings (spacing). The research that exists in other fields has focused primarily on the effect of small gaps (less than one year), and on very early outcomes such as birth weight and gestation. Evidence of the effect of spacing on later outcomes such as childhood health or educational attainment would add to our understanding of the effects of family structure. In fact, some of the hypothesized mechanisms for birth order effects, such as differential parental investments, could be mitigated by spacing (Zajonc 1976). Furthermore, unlike birth order or (for the most part) gender composition, spacing is a matter over which parents might have some control. Empirical evidence of a causal effect of gap size on children's outcomes would be helpful for parents making decisions about the timing of their fertility.

Additionally, policy makers in both developed and developing countries have advocated greater spacing between births as a means of improving maternal and infant health. For example, the United States Agency for International Development has issued a policy brief entitled "Healthier Mothers and Children Through Birth Spacing," which uses the popular phrase "three to five saves lives."[1] The Contra Costa County Health Services Department in California conducted a public health campaign in 2007, which advocated greater spacing with the slogan "Just Us for Two Years."[2] These policies may have unintended consequences if spacing affects later life outcomes.

In this paper, we investigate the effects of birth spacing on one important outcome: educational achievement as measured by performance on the Peabody Individual Achievement Tests for math and reading. We use the fertility histories of women with multiple children in the 1979 National Longitudinal Survey of Youth, and observe the spacing between each sibling pair. We then match the data to the NLSY79 Children and Young Adults survey, which contains detailed information on the children in the sibling pairs. We use OLS to estimate the effects of spacing on outcomes, separately for the older and younger child in each pair. The OLS results suggest that longer gaps improve test scores for older children but have negative effects for younger children, and the effects vary by socioeconomic status, birth order, and gender.

Because we are concerned that spacing may be correlated with unobservable characteristics, we also use an instrumental variables strategy to identify the causal effect of spacing on sibling outcomes. The identification strategy exploits variation in spacing driven by miscarriages that occur between two live births. We show that a miscarriage between siblings increases the gap between them by about ten months on average, and decreases the probability

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[1] http://www.usaid.gov/our_work/global_health/pop/news/issue_briefs/healthy_birthspacing.pdf
[2] http://cchealth.org/press_releases/birth_spacing_campaign_2007_08.php

that the gap is under two years by 0.18. We argue that miscarriages of this nature are not likely correlated with the error term, as discussed in Section V. The IV results are imprecise, but we find that an increase in spacing of one year increases reading scores for older, low-SES children by about 0.15 standard deviations. This effect is comparable to estimates of the effect of birth order and larger than estimates of the effect of increasing family size by one. For these same children, spacing of less than two years has a large negative effect, decreasing reading scores by 0.87 standard deviations.

The remainder of the paper is organized as follows: Section II provides some background on birth spacing and discusses potential mechanisms for an effect of spacing on outcomes. Section III summarizes the data, and Section IV presents results using OLS estimation. The instrumental variables strategy is discussed in detail in Section V, and the IV results are presented in Section VI. Section VII concludes.

II. Birth Spacing: Background

A. Previous Research

Much of the previous research on birth spacing comes from the medical literature, where the focus is on the effects of conceiving soon after a previous birth. Evidence on the effect of shorter spacing between births on neonatal and birth outcomes is mixed. For example, Smith et al. (2003) find that interpregnancy intervals shorter than 6 months were associated with increased risks of preterm birth and neonatal death in the second birth, though Stephansson et al. (2003) show these risks are not significantly greater for birth intervals of zero to three months. Brody and Bracken (1987) find that women conceiving within 9 months of a prior live birth were at increased risk of delivering a low birth weight newborn compared with women conceiving 9 or more months after a prior birth. However, in a large sample of women in Denmark, Basso, Olsen, and Christensen (1998) find that interpregnancy intervals of less than 8 months were associated with preterm delivery but found no effect on low birth weight. Smits and Essed (2001) and van Eijsden et al. (2008) suggest nutritional depletion—in particular folate—as a mechanism through which spacing might affect birth outcomes. More recently, in a study of sibling pairs in California, Cheslack et al. (2011) estimate that second-born children conceived within 12 months of a previous birth have three times the odds of being diagnosed with autism than those conceived more than 36 months after a previous birth. The authors suggest that this could be driven by both physiological and social factors. For example, parents of children that are spaced more closely together may be more likely to notice developmental differences between their children so younger children in these families may be more likely to receive an early autism diagnosis.

Social scientists have also been interested in the effects of birth spacing. Building on a confluence model presented by Zajonc and Markus (1975), where family size and birth order influence the intellectual environment, Zajonc (1976) argues that the effects of birth order "are mediated entirely by the age spacing between siblings," and that greater spacing between siblings can reverse the negative effects of birth order. The argument is that children born into families with older children are born into more favorable intellectual environments. In this model, larger gaps may also positively affect first-born children, who have more time to develop before the birth of an "intellectually immature" younger sibling. Additional evidence is provided by Broman, et al., (1975), who found that children born after longer intervals scored higher on the Stanford-Binet scale than those born after shorter intervals. However, Galbraith (1982) finds that sibling spacing had no effect on intellectual development in a sample of predominantly

Mormon college students.

Among economists, Rosenzweig (1986) and Rosenzweig and Wolpin (1988) show that unobserved family heterogeneity leads to biased estimates of birth spacing on child outcomes. Heckman, Hotz, and Walker (1985) examined determinants of birth spacing and found that for a sample of married and unmarried women, previous birth intervals were negatively correlated with spacing between subsequent children after controlling for unobservables. More recently, Heckman and Walker (1990) considered the effects of female labor market outcomes on fertility timing and birth spacing and found that higher female wages led to delayed childbearing and greater spacing between children. However, there is little empirical evidence on the effect of birth spacing on child outcomes.

B. Potential Mechanisms

Birth spacing could affect child outcomes through a number of channels. Spacing affects parental investments, which may influence child outcomes; for example, Price (2008) finds that parents spend about 3,600 more hours with first-born children during their childhood than with second-born children. Following the confluence model of Zajonc (1976), older children may benefit from teaching younger children, the effect of which may vary by birth spacing. To the extent that bigger gaps between children allows an older child to develop more, the benefit to a younger sibling of learning from an older sibling may increase as birth intervals increase. We expect that this might have positive effects in particular on vocabulary development of a younger child. Spacing may also affect a younger child’s receptiveness to an older sibling. Cicirelli (1973) finds that younger siblings were more likely to accept direction from a sibling that is 4 years older than one that is two years older and suggests that while siblings with greater spacing may interact less than those with less, the widely spaced older children may model cognitive tasks more effectively for their younger siblings. Alternatively, having children closer together may decrease the per child cost of certain inputs, both in terms of physical resources (e.g., sharing clothes and toys) and time intensive activities (e.g., reading to children) so that children benefit from tighter spacing (Jones, 2009). Sharing resources with a younger, less mature, child may also impede intellectual development of an older sibling or lead to sibling rivalries, in which case outcomes for an older sibling would be negatively correlated with spacing (Zajonc, 1976). The extent to which sibling spacing affects child outcomes could vary depending on other child characteristics. Koch (1954) and Rosenberg and Sutton-Smith (1969) find that close sibling spacing has positive effects for females, but negative effects for males.

Evidence from related research on family structure suggests that family composition may affect families differentially based on SES and race. Dahl and Moretti (2008) show that the effect of a female first-born child declines monotonically with education, and has virtually no effect on families where the parent is a college graduate; these effects also vary by race, where the largest effect is for Asian children and the smallest effect is for white children. Kaestner (1997) finds sibling composition effects only among children of black teen mothers. In contrast, Black, Devereux, and Salvanes (2005) find that birth order effects are slightly stronger for children of women with more education. Findings from other research may be related to sample restrictions based on SES or race. For example, Hanushek (1992) attributes declines in child test scores in part to increasing family size using data from the Gary Income Maintenance Experiment, which only includes low-income black families. Price (2010) finds a positive and significant effect of reading to children on reading test scores in a sample of children from two-parent families in the NLSY. Similarly, Galbraith (1982) finds no effect of sibling spacing on intellectual development in a sample of predominantly Mormon college students. This suggests that the effects of spacing might be heterogeneous, in particular if sibling spacing effects are driven partly by financial constraints.

III. Data

The data for this study come from the National Longitudinal Survey of Youth, 1979 (NLSY79). The NLSY79 is a nationally representative panel survey of 12,686 respondents, who were age 14-22 in 1979. Our sample will contain women from the NLSY79, for whom detailed fertility histories are available. From these histories, we are able to observe how many pregnancies each woman has had, the outcome of each pregnancy, and its timing. For our study, we use women with at least two live births, since we are interested in the spacing between them. Each observation is a sibling pair, where the pair consists of siblings adjacent in birth order.

For each sibling pair, we observe the gap in days between their births. We limit the sample to gaps among the first three live births and to gaps of less than ten years, which gives us 4,777 observations (twins are omitted from the sample). Of these, 3,243 were between 1st and 2nd children (gap 1-2) and 1,534 gaps were between 2nd and 3rd children (gap 2-3). Figure 1a shows the distribution of the gap between 1st and 2nd children in the NLSY79, in months. The mean gap is 40.7 and the median is 34.[3] As a check on the reliability of the data in the NLSY79, we compare the data to information on sibling spacing obtained from the 1986 Natality Detail Files. This data set contains birth certificate information for virtually all children born in the United States in 1986, which is the mean year for second births in the NLSY. We use information on the number of months since the mother's last live birth, for the 778,126 second-born children in the data with between 9 months and 10 years since the previous birth. The

[3] These numbers vary slightly from those in Table 2 because the spacing measure here is converted to integer months for comparability with the Natality data.

distribution generated by the Natality data is shown in Figure 1b, and the two data sets generate remarkably similar results. In the Natality data, the mean gap in months between first and second births is 39.5 and the median is 33.

After constructing the sibling pairs from the NLSY79, we link these observations to information on the siblings obtained from the NLSY79 Child and Young Adult Survey. This data set contains information on the children born to the women of the NLSY79, and allows us to observe outcomes such as test scores for the siblings in each pair. Children are matched to their mothers' fertility histories by unique mother identifiers. We will consider the effects of spacing for the older and younger child in the sibling pair separately.

Table 1 presents summary statistics for the siblings and sibling pairs.[4] Test scores are math and reading scores from the Peabody Individual Achievement Test (PIAT), which measures academic achievement of children ages 5 to 18. Because the Child and Young Adult Survey is administered biennially and the ages at which a child takes the tests vary, we use age-adjusted scores from the first available score in each test.[5] Nearly 80 percent of the children in our sample took the PIAT for the first time between ages 5 and 7. Raw PIAT scores ranged from 1 to 84 in our data. The test score means show that higher birth-order children score better on the tests, consistent with previous research on birth order (Black, Devereux and Salvanes 2007).

The NLSY79 fertility histories also allow us to observe whether any pregnancy occurred between siblings that resulted in an outcome other than a live birth. The histories indicate the timing of the pregnancy, and whether the pregnancy ended in a live birth, miscarriage, stillbirth, or abortion. Out of 4,777 sibling pairs for whom complete fertility histories are observed, a

[4] Differences in race and total number of children between older and younger children are the result of using the child weights.
[5] To age-adjust the scores, we regressed each score on a child's year of birth, captured the residuals from the regression, and normalized the residuals to have a standard deviation of one.

miscarriage or stillbirth occurred between the siblings in 292 cases. Miscarriages were slightly more common in gap 1-2 than in gap 2-3 (see Table 1). The miscarriage data will be useful for our identification strategy, which we summarize in more detail in Section V below.

In Table 2, we investigate how observable characteristics are correlated with spacing for our sample. In the first two columns, we regress the time between siblings (in months, measured as days/30) on the sex of the older child and on demographic characteristics of the mother. Results are shown separately for gaps 1-2 and gaps 2-3. Not surprisingly, women with more total children have smaller gaps between them. Women who were married at the time of their first birth also have smaller intervals before the second child. Hispanics have slightly longer birth intervals, and there is a marginally significant effect of the second child's gender on the interval to the third child. However, age, education, AFQT score, and high family income are not practically or statistically significant predictors of birth spacing in months. Child year-of-birth dummies were also added to this regression and do not reveal a meaningful time trend in birth spacing.

We also consider the relationship between these observable characteristics and the likelihood of having spacing of less than two years. We are interested in this measure because some of the mechanisms discussed above would be especially relevant for short gaps. For example, research on the adverse physiological effects of close spacing have focused on intervals less than one or two years (Smith, et al., 2003; Basso, Olsen, and Christensen, 1998; Brody and Bracken, 1987). We choose a point of two years because public policy initiatives have typically advocated for spacing of more than two years. Also, because the mode of the spacing distribution is around two years, we are able to obtain precise estimates of the effect of spacing below this point.[6]

The last two columns of Table 2 indicate that women who were married at the time of their first birth are more likely to have a gap less than two years between their first and second child and less likely to have a gap less than two years between their second and third children. Education is negatively correlated with the probability of having a gap less than two years before the third child. As with spacing measured in months, age, race, AFQT score, and high family income are not significant predictors of spacing intervals less than two years.

IV. Estimation: OLS

We begin by estimating the effects of birth spacing on sibling outcomes using OLS. The model to be estimated is:

$$Score_{is} = \beta_0 + \beta_1 * gap_i + X_s\, \beta_2 + Z_i\, \beta_3 + u_{is}$$

where the subscript i indexes a sibling pair and s indicates whether the variable describes the older or younger sibling of the pair. In all regressions, the effect of the gap is estimated separately for the older and younger sibling. The dependent variable is the standardized, age-adjusted PIAT score in math or reading recognition.[7] The variable gap_i is the time between the births of the two siblings, in months, or a dummy variable equal to one if the time between births is less than two years.[8] The vector X_s is a set of characteristics specific to child s of the pair,

[6] For the test score analysis below, we have considered alternative definitions of close spacing , including one and three years. Because only a small fraction (less than 3%) of our sibling gaps have spacing less than one year, IV results using this cutoff are very imprecise. For cutoffs between two and three years, the results are similar to those using our two-year measure but are generally less precisely estimated.

[7] We also produced results using the PIAT reading comprehension scores; results were very similar to results for reading recognition and so we omit them here for brevity.

[8] In results not shown here, we allowed for a non-linear relationship between spacing and test scores. In all cases, we failed to reject the linear specification.

including gender, race, birth order, and a set of year of birth dummies. Z_i is a vector of characteristics common to both children in the pair, and includes the mother's age at first birth, number of total children, marital status at first birth, highest degree obtained, and adjusted AFQT score; u_{is} is error. All regressions are limited to sibling pairs that are less than ten years apart. Estimates are weighted by NLSY child sampling weights. Because a mother with more than two children will have more than one sibling pair in the data set, standard errors are clustered at the individual mother-level.

The potential mechanisms discussed above suggest that the effects of spacing may be heterogeneous. For example, if financial constraints are important, we might see different effects by SES. Therefore, we consider spacing effects separately for high- and low-SES groups. Income is chosen as an SES measure because we are interested in the effects of spacing when resources are constrained. However, we are concerned that income could be affected by spacing, in which case we are selecting on an endogenous variable. The measure we use (described below) is a broad measure and we think it is unlikely that many families are moved from one income group to the other by spacing, but for this reason we also use cognitive ability as a measure of SES. Our measure of cognitive ability (described below) is observed before fertility in most cases and is likely exogenous with respect to spacing.

To construct income groups, we use total net family income and poverty status in the first year following the birth of the younger child in a sibling pair for which the income measure is available.[9] When the younger child was born before 1977, we use total net family income in 1979. We consider income at the birth of the younger child; total net family income at the birth

[9] Total net family income includes military, business, farm, and other employment earnings from all related household members as well as other income such as welfare payments, disability payments, and food stamps. For a complete list of income components, see http://www.nlsinfo.org/nlsy79/docs/79html/codesup/app2tnfi.htm.

of the second child is available for 2,369 observations in our sample and 1,261 observations have values for total net family income at birth of the third child. In cases where total net family income is not available within two survey years of the birth of the younger child but poverty status is available, we impute an income of zero for families below the poverty line and the maximum income value for families above the poverty line. In total, we impute income values for 1,027 second births (30 percent of all second birth income values) and 317 third births (20 percent of all third birth income values). Using this imputed income measure, we calculate median income at the birth of the younger child in a sibling pair, and in each case create a binary variable equal to one for families above median income and zero for those below. Median income in our sample is $31,950 at the birth of the second child (available for 3,396 observations) and $23,246 at the birth of the third child (available for 1,578 observations).

For our alternative measure of socioeconomic status, we create a measure of ability using percentile scores from the Armed Forces Qualifying Tests (AFQT). The AFQT is a composite of scores from four tests administered to most NLSY respondents in 1980 that measure knowledge of typical high school level subjects (arithmetic reasoning, word knowledge, paragraph comprehension, and numerical operations). AFQT scores are frequently used as a measure of cognitive ability and are highly correlated with educational attainment and post-education earnings in our sample. To measure whether a respondent is above or below median ability as measured by the AFQT, we calculate the median AFQT percentile in our sample, and create a binary variable equal to one for respondents with scores above the median, and zero for those below. The median AFQT percentile score in our sample is 29.

OLS results are presented for math and reading scores in Table 3 for older siblings and in Table 4 for younger siblings. For each set of regressions, specification [1] is a simple regression of test score on the gap in months, while specification [2] adds the above controls. In the discussion that follows, we focus on results with controls. The first row presents results for the full sample, and we see that for older children, there is a small and statistically significant effect of spacing on test scores when controls are included. A one-year increase in spacing is associated with an increase in scores of 0.024 SD for math and 0.017 for reading. Likewise, spacing of less than two years is associated with a 0.139 SD decrease in math scores and a 0.101 decrease in reading scores. For younger siblings, however, greater spacing is associated with lower test scores, with estimated effects of a one-year increase in spacing of -0.019 SD for math and -0.020 SD for reading. Results for gaps of less than two years for younger children are imprecise, but suggest that small gaps are associated with lower math but higher reading scores for younger siblings.

In the remaining rows of Table 3 and Table 4, we show results by socioeconomic status. It appears that the beneficial effect of spacing for older children is confined to low-AFQT and low-income mothers when looking at the spacing measure in months. Gaps of less than two years are associated with lower scores for both high- and low-SES families, though the relationship is only statistically significant for low-income families. On the other hand, the negative effect of spacing in months for younger children is concentrated among high-SES families. Children in low-income families with gaps less than two years have lower test scores for both math and reading than those with spacing greater than two years.

In Table 5, we allow for the effect of spacing to vary by birth order and gender. The results show that for older siblings, the positive relationship between spacing and reading scores only holds for gap 1-2; that is, greater spacing before the next child benefits the first- but not the second-born. This might be the case if spacing allows these children to benefit from being the only child for a longer period, during which they might receive greater resources from the parents (this is the mechanism suggested by Price (2010)). There is also evidence that the beneficial effects of spacing are greater for boys than for girls, consistent with Smith (1969). For reading scores, the negative effects of a gap of less than two years only hold for gap 1-2 and for girls. There are no important differences in the relationship between test scores and spacing by birth order or gender for younger siblings.

The results in this section show that longer spacing between siblings is associated with higher test scores for older siblings and in some cases lower scores for younger siblings, with effects that vary by SES and child characteristics. However, our results may be biased if spacing between siblings is correlated with unobservable characteristics of the mother or children. For example, if families with larger gaps between children are more likely to have planned their births, and planning is correlated with better outcomes, these results may have a positive bias. OLS estimates could also be negatively biased if families decide to have another child sooner if the older child is better "quality" (in good health, for example, which is the concern of Rosenzeweig (1986)). The negative bias would arise because small gaps would be correlated with better unobservable characteristics for the older sibling and also with the younger if sibling characteristics are correlated. Finally, parents may plan the spacing of their children in an attempt to achieve certain outcomes, confounding the effects of spacing on child outcomes.[10] In order to address this endogeneity problem, we employ an identification strategy that uses miscarriages as exogenous factors that affect birth spacing.

[10] Because there appears to be little popular consensus about how spacing affects child outcomes, we are less concerned about this problem in our analysis.

V. Miscarriages as an Instrumental Variable

We will use miscarriages that occur between two live births as an instrument for birth spacing. A miscarriage is a pregnancy that is lost before the 20th week of pregnancy. [11] Ten to twenty percent of confirmed pregnancies end in a miscarriage, and as many as 50 percent of all conceptions are thought to end in a miscarriage (American College of Obstetricians and Gynecologists, 2002). More than 80 percent of miscarriages occur in the first 12 weeks of pregnancy (Cunningham, et al., 2010).

What is important for our estimation strategy is that a miscarriage between two siblings induces a delay in the birth of the second child—the next live birth now occurs after the woman miscarries, conceives again, and gives birth. Estimates of average time to conception after a miscarriage for women who conceived within one year of a miscarriage range from 17.35 weeks (Goldstein, Croughan, and Robertson, 2002) to 23.2 weeks (Wyss, Biedermann, and Huch, 1994). This would generally increase the average spacing between children by about 6 to 8 months (assuming a mean of around 8 weeks gestation at miscarriage).[12] Figure 2 shows the distribution of birth spacing for women who do and do not have a miscarriage between live births. A miscarriage appears to shift the spacing distribution to the right; we use OLS to estimate the effect of a miscarriage on birth spacing for our NLSY79 sample below.

Miscarriages have been used as an instrument for fertility timing in previous research in economics. For example, Hotz, McElroy, and Sanders (1997, 2005) use miscarriage as an instrument to identify the effect of delayed childbearing on teenage mothers' socioeconomic

[11] Pregnancies that end in a fetal death after 20 weeks are classified as stillbirths. In our sample, about 6% of fetal deaths are stillbirths; these few stillbirths are counted as miscarriages for the purposes of estimation.
[12] Our full sample includes women who conceive more than one year after a miscarriage, so our estimated effect of the effect of miscarriage on spacing is larger.

attainment. Miller (2009) uses biological fertility shocks, including miscarriage, to instrument for the age at which a woman bears her first child in her analysis of the effects of delayed childbearing on subsequent earnings. Hotz, Mullin, and Sanders (1997) show that miscarriage is an appropriate instrumental variable for women who experience random miscarriages, and use this instrument to explore the effect of teenage childbearing on teen mothers' outcomes.

However, Lang and Ashcraft (2006) have criticized using miscarriage as an instrument because some miscarriages may prevent abortions that would have taken place ("latent" abortions), while other miscarriages would have occurred in pregnancies that were aborted. However, because all the women in our sample had a live birth on either side of the miscarriage, we believe these conceptions were less likely to be latent abortions and are more likely to be random events. Among women in the NLSY79, only 3.3% report having an abortion between their first and second live birth, while 7.9% of women report having an abortion in their first pregnancy.[13] These numbers raise an additional concern, however, which is that miscarriages are underreported in the NLSY79. Systematic misreporting of miscarriage among women who intentionally aborted would bias our estimates (Elwood, 2004). Using a similar sample of women with children in the NLSY79, Miller (2009) finds that misreporting is unsystematic in terms of religious beliefs, a likely correlate of misreporting. As in Hotz, Mullin, and Sanders (1997), we assume that underreporting of miscarriages is random with respect to child outcomes; to the extent that women underreport miscarriages randomly, this would downward bias our estimates.

[13] The Guttmacher Institute (2008) reports that 60 percent of abortions are obtained by women who have at least one child, though this number is surely lower for women who go on to have another birth.

The IV estimates would also be invalid if miscarriages are correlated with unobservable characteristics of the mother or child. Chromosomal abnormality in the fetus is the most common reason for a miscarriage, accounting for over 50 percent of known pregnancies during the first 13 weeks (American College of Obstetricians and Gynecologists, 2002; Cunningham, et al., 2010). In most instances, the abnormality is a random occurrence and is not associated with higher risk of miscarrying in the future. Other risk factors include maternal age, multiple births, maternal illness or trauma, hormonal imbalances, and other reproductive issues (American College of Obstetricians and Gynecologists, 2002; Cunningham, et al., 2010). Behaviors such as drug use, alcohol abuse, and smoking, are also correlated with miscarriage, as are community-level risk factors (Fletcher & Wolfe, 2008; Mullin, 2005).[14] Finally, women are more likely to miscarry after having a boy, possibly due to immune responses of the mother (Nielsen et al. 2008).

To explore the extent to which miscarriages might be associated with observable and unobservable characteristics, Table 6 presents marginal effects from probit regressions of a dummy for a miscarriage between births on characteristics of the first birth and of the mother at first birth. Results are shown for the full sample and by SES. For the full sample, the only characteristics that appear to be associated with the risk of a later miscarriage are mother's race, the gender of the first child (which was expected), and whether the pregnancy was after the first or second child. All other variables are statistically insignificant, and the null hypothesis that all covariates are jointly insignificant cannot be rejected at the 20% level. For the subsamples, results are generally similar and the R-squared and overall F-statistics suggest that miscarriages

[14] We can control for alcohol use and smoking for a subset of our sample, and results are not affected by their inclusion.

are largely unexplained by observable characteristics. Nevertheless, in all results below we add them as controls.

A remaining concern is that the miscarriage itself could have a direct effect on children's outcomes, in particular through psychological and physiological changes that affect maternal health. A number of studies show that women who experience a miscarriage are more likely to suffer from depression and anxiety (Armstrong, 2002; Armstrong and Hutti, 1998; Neugebauer, et al., 1992). However, previous research also suggests that these symptoms decrease over time and disappear 12 months after a miscarriage (Thapar and Thapar, 1992; Janssen, et al., 1996; Hughes, Turton, and Evans, 1999). Women who have a healthy pregnancy following a miscarriage or stillbirth might also be at decreased risk for depressive symptoms (Swanson, 2000; Theut, et al., 1989). Other evidence suggests that women are less attached to children born after a stillbirth, which could lead to later developmental problems (Hughes, et al., 2001) but miscarrying appears to have no effect on investment or early life outcomes in subsequent children (Armstrong, 2002; Theut, et al., 1992).

Another concern is that conceiving too quickly after a miscarriage may affect development of the fetus in a subsequent birth.[15] Swingle, et al., (2009) find that women are at greater risk of having a preterm birth following a miscarriage, though Wyss, Biedermann, and Huch (1994) show that women who had already given birth to a child prior to a miscarriage are at lower risk of delivering prematurely than those who had not previously given birth. Kashanian, et al., (2006) and Wyss, Biedermann, and Huch (1994) find that the length of interpregnancy interval following a miscarriage has no effect on neonatal complications.

[15] Wyss, Biedermann, and Huch (1994) consider the effect of remnants of chorion, placenta, or villi from the previous miscarriage, as well as persistently high hCG levels, on fetal development in a subsequent pregnancy.

Importantly, most evidence suggests that miscarriage would have negative effects, if any, on subsequent children, which works in opposition to our findings below that increased spacing (when instrumented with miscarriages) has positive effects on child outcomes. Few studies have found a positive effect of past miscarriage on subsequent pregnancies. We know of one paper, Todoroff and Shaw (2000), that finds evidence that women whose immediate past pregnancy ended in a miscarriage have a slightly lower risk of neural tube defect (NTD) than those whose past pregnancy ended in a live birth, which has been associated with low birth weight, preterm birth, and neonatal death.

The second requirement for using miscarriages as an IV for birth spacing is that the two variables are correlated—that is, that the first stage is valid. Our results in Table 7 show that this is the case. We control for demographic characteristics of the mother, and for child gender, birth order, and year-of-birth dummies. For older children, a miscarriage before the birth of the next child is associated with an increase in spacing of about ten months or a -0.18 decrease in the probability of having a gap smaller than two years between children, with some heterogeneity by family income. For younger children, the estimated effect is slightly smaller and also statistically significant.[16] The F-statistics are over 10 in all but one case, alleviating concerns about a weak instrument. [17]

[16] Results are slightly different when calculated for older and younger children because the characteristics of younger children (used as controls) are different on average, and because child--specific weights are used.
[17] We also add controls for smoking and drinking during the first pregnancy for the smaller sample for which this information is available; the effect of a miscarriage on spacing is nearly identical in both specifications.

VI. Instrumental Variables Results

IV results for the effect of spacing on test scores are presented in Table 8. We find that a one-year increase in spacing is predicted to increase reading scores by 0.22 SD for low-AFQT families and by 0.15 for low-income families. Similarly, having children spaced less than two years apart is predicted to decrease reading scores by 1.08 SD for low-AFQT families and 0.87 SD for low-income families. These effects are larger than those estimated by OLS, which suggests that the OLS estimates are biased downward. This is what we would expect if (for example) a "high quality" older child leads parents to have the next child sooner (Rosenzweig 1986). For comparison, estimates of the effect of birth order on IQ scores range from 0.2 (Black, Devereaux, and Salvanes 2007) to 0.25 SD. Increasing family size by one through twins decreases IQ scores by about 0.08 SD (Black, Devereaux, and Salvanes 2010). For younger siblings, we find no statistically significant effects of spacing on test scores.

IV estimates by birth order and gender are shown in Table 9 for the low-income sample of older children. Results are again imprecise, but the magnitudes indicate that the beneficial effects for older children may be concentrated among first births, in particular for reading, again suggesting that first-born children may benefit from additional time as an only child. Coefficients are also greater for girls rather than boys. These results are qualitatively different from those produced by OLS, though the imprecision of the estimates does not allow us to reject the null hypothesis that the OLS and IV results are the same.

VII. Conclusion

In this paper, we have examined the relationship between birth spacing and sibling test scores. OLS results suggest that greater spacing is beneficial for older siblings but harms younger siblings, and the effects vary by socioeconomic status and child characteristics. However, we are concerned that these results are biased by omitted child and family characteristics that are correlated with birth spacing. To address this issue, we use miscarriages that occur between live births as an instrument for child spacing. First stage estimates indicate that a miscarriage increases the time from first to second birth by about 10 months and decreases the probability of having children born less than two years apart by 0.18.

Our instrumental variables results are imprecise but we do find that an increase in spacing of one year increases reading scores for older children in low-SES families by about 0.15 SD. This is comparable to previous estimates of the effect of birth order on IQ scores and larger than estimates of the effect of increasing family size by one. Similarly, spacing children less than two years apart decreases reading scores for older children by about 0.87 SD. Thus, it appears that spacing could be an important channel by which family structure could influence child outcomes, particularly for low-SES families.

Our findings also suggest that public policies that encourage greater interpregnancy intervals for health reasons could have other unanticipated effects. We have investigated the effect of spacing on test scores, but sibling spacing might also affect health, educational attainment, or likelihood of engaging in risky behaviors. We hope to use future waves of the NLSY79 Children and Young Adults Survey to consider these other outcomes.

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Figure 1a: Distribution of Gap Between First and Second Child, NLSY79

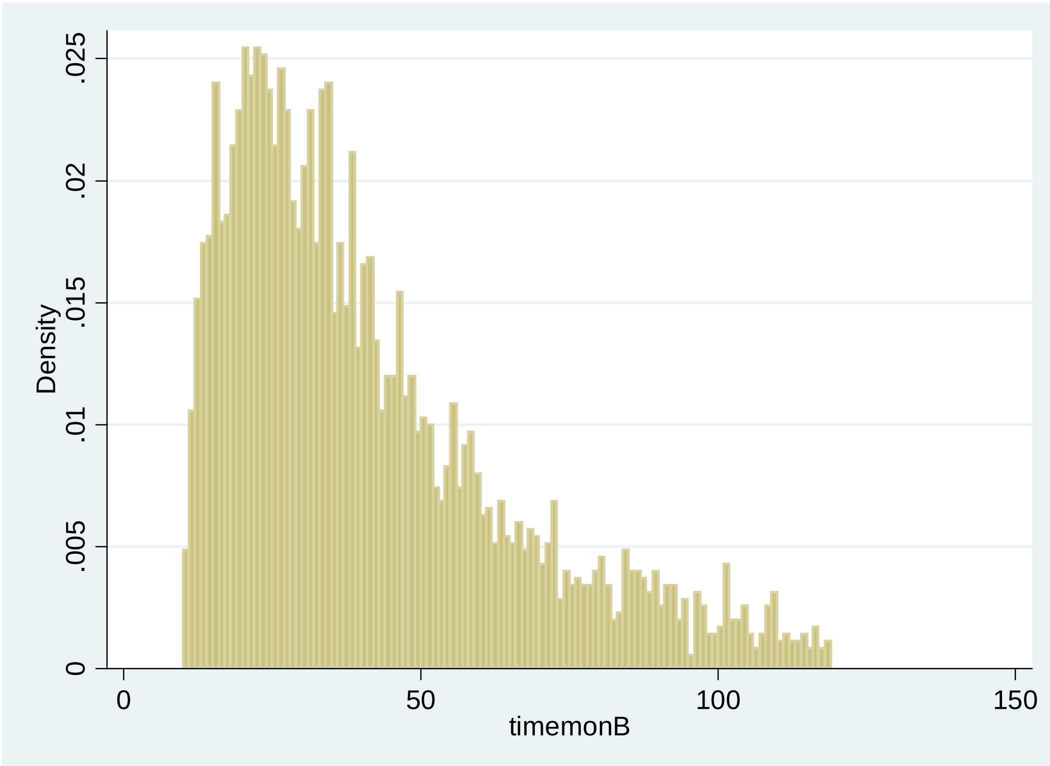
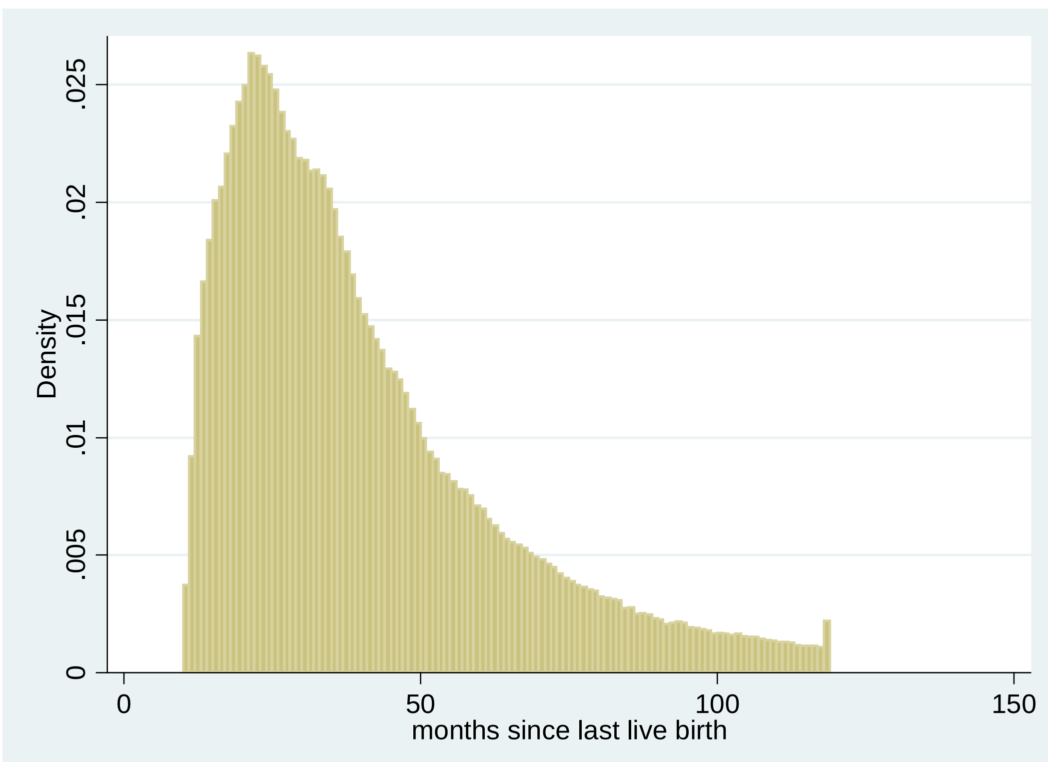
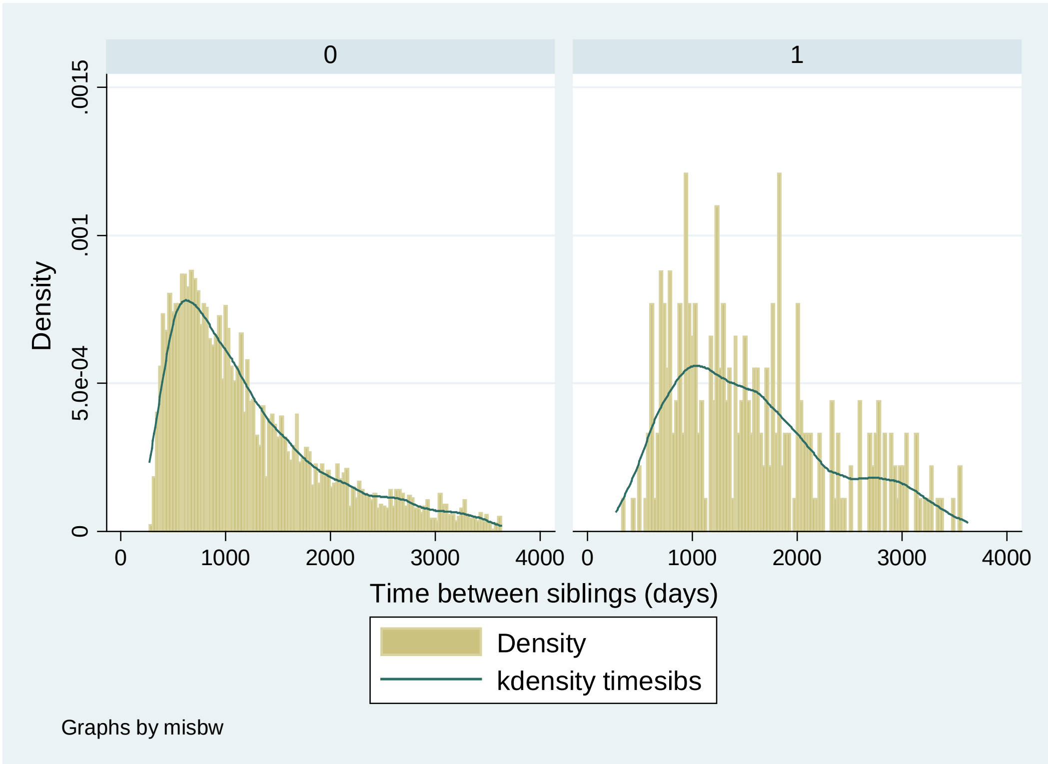


Figure 1b: Distribution of Gap Between First and Second Child, 1986 Natality Detail Files



Samples are restricted to intervals greater than 9 months and less than 10 years.

Figure 2: Distribution of Birth Spacing in NLSY79, by Miscarriage



Sample is restricted to intervals greater than 9 months and less than 10 years.

Table 1: Summary Statistics for Children in Sample

	Gap Between Child 1 and 2		Gap Between Child 2 and 3	
	Child1	Child2	Child2	Child3
Birth Year	1984.68	1987.88	1986.24	1989.36
	(5.87)	(5.67)	(5.49)	(5.25)
Female	0.4908	0.4709	0.4650	0.4934
	(0.5000)	(0.4992)	(0.4989)	(0.5001)
Hispanic	0.0834	0.0787	0.0990	0.0923
	(0.2765)	(0.2694)	(0.2988)	(0.2895)
Black	0.1668	0.1597	0.2024	0.1916
	(0.3728)	(0.3664)	(0.4019)	(0.3937)
Total Number of Children, by 2006	2.67	2.67	3.51	3.54
	(0.95)	(0.94)	(0.89)	(0.91)
PIAT Score, Math	22.14	19.71	19.70	18.51
	(12.35)	(10.33)	(10.84)	(10.23)
PIAT Score, Reading	24.77	21.17	21.28	19.95
	(13.65)	(11.18)	(11.54)	(11.11)
Observations	3,243		1,534	
Mean Months Between	41.46		42.50	
	(23.24)		(25.51)	
Median Months Between	34.53		35.50	
Fraction <2 Years Apart	0.2413		0.2700	
	(0.4279)		(0.4459)	
Miscarriage Between Siblings	0.0761		0.0469	
	(0.2652)		(0.2115)	

Each observation is a sibling pair. Standard deviations are in parenthesis. Child weights are used, and the sample is restricted to intervals less than 10 years.

Table 2: OLS Regressions of Spacing on Characteristics of Mother and Older Child

	Dep. Var: Gap in Months		Dep. Var: =1 if Gap < 2 Years	
	Gap 1	Gap 2	Gap 1	Gap 2
Older Child is Female	-0.9877	2.9771*	0.0018	-0.0236
	(0.9766)	(1.6311)	(0.0183)	(0.0288)
Hispanic	2.8195*	3.6844	0.0057	-0.0429
	(1.4643)	(2.4300)	(0.0254)	(0.0395)
Black	1.3619	1.7156	0.0332	-0.0123
	(1.5316)	(2.5215)	(0.0258)	(0.0420)
Total Number of Children, by 2006	-5.6331**	-4.2462**	0.1004**	0.0768**
	(0.5127)	(0.8459)	(0.0109)	(0.0167)
Age at First Birth	0.0023	0.002	-0.0001*	0.0001
	(0.0037)	(0.0058)	(0.0001)	(0.0001)
Age at First Birth^2	0.0000	0.0000	0.0000*	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Never Divorced/Separated	-1.3857	-0.4964	-0.0144	-0.0810**
	(1.0567)	(1.7736)	(0.0196)	(0.0308)
Married at First Birth	-5.2036**	1.9376	0.0761**	-0.1338**
	(1.4652)	(2.3050)	(0.0230)	(0.0408)
High School Degree	2.2301	-0.5851	-0.0238	-0.0701*
	(1.4349)	(2.2907)	(0.0261)	(0.0385)
College Degree	1.6145	2.0847	-0.0357	-0.1103*
	(1.9672)	(3.4930)	(0.0378)	(0.0611)
AFQT	0.0159	-0.0364	-0.0009*	-0.0001
	(0.0234)	(0.0443)	(0.0005)	(0.0008)
High Family Income	-0.8483	1.3583	-0.004	-0.0028
	(1.1757)	(1.9724)	(0.0218)	(0.0336)
Observations	2,905	1,338	2,905	1,338
R-squared	0.0830	0.0592	0.0739	0.0592
Dependent Variable Mean	41.46	42.50	0.24	0.27
[Std. Dev.]	(23.24)	(25.51)	(0.43)	(0.45)

**, * Denote signifigance at 5% and 10% respectively. Each observation is a sibling pair, and the dependent variable is spacing between the siblings, in months, and a dummy variable equal to one if spacing is less than two years. Child weights are used, and robust standard errors are in parenthesis. Sample is restricted to intervals less than 10 years.

Table 3: OLS Estimates of Effect of Spacing on Test Scores, OLDERS

	Spacing Measure: Gap in Months				Spacing Measure: Gap < 2 Years			
	PIAT-Math		PIAT-Read-Cog		PIAT-Math		PIAT-Read-Cog	
Sample:	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]
All	0.0004	0.0020**	0.0003	0.0014**	-0.1888**	-0.1385**	-0.1433**	-0.1011**
	(0.0007)	(0.0007)	(0.0008)	(0.0007)	(0.0447)	(0.0412)	(0.0454)	(0.0410)
	4,398	4,217	4,391	4,212	4,398	4,217	4,391	4,212
High AFQT	-0.0004	0.0009	-0.0002	0.0006	-0.1084*	-0.1153**	-0.0706	-0.0760
	(0.0010)	(0.0010)	(0.0011)	(0.0010)	(0.0611)	(0.0588)	(0.0637)	(0.0595)
	2,064	2,064	2,062	2,062	2,064	2,064	2,062	2,062
Low AFQT	0.0027**	0.0025**	0.0010	0.0013	-0.2079**	-0.1096**	-0.1367**	-0.0848
	(0.0009)	(0.0009)	(0.0009)	(0.0008)	(0.0561)	(0.0532)	(0.0597)	(0.0580)
	2,104	2,021	2,100	2,019	2,104	2,021	2,100	2,019
High Family Income	-0.0003	0.0013	0.0006	0.0011	-0.1520**	-0.1419**	-0.1124*	-0.0849
	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0632)	(0.0602)	(0.0612)	(0.0559)
	2,036	1,966	2,033	1,963	2,036	1,966	2,033	1,963
Low Family Income	0.0030**	0.0030**	0.0022**	0.0019**	-0.2208**	-0.1718**	-0.1814**	-0.1179**
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0550)	(0.0523)	(0.0511)	(0.0486)
	2,153	2,153	2,150	2,153	2,153	2,153	2,150	2,150
Additional Controls		x		x		x		x
Year of Birth Dummies		x		x		x		x

**, * Denote signifigance at 5% and 10% respectively. Each entry is from a separate regression and gives the coefficient on spacing, in months, for the indicated sample and specification. Each observation is a sibling pair, and child weights are used. Additional controls include child gender and mother's race, age at first birth, education, number of children, marital status at first birth, and AFQT score. See text for definitions of AFQT and income categories. Test scores are age-adjusted and standardized. Standard errors are clustered by mother and are in parenthesis; number of observations is given below the standard error. Sample is restricted to intervals less than 10 years.

Table 4: OLS Estimates of Effect of Spacing on Test Scores, YOUNGERS

	Spacing Measure: Gap in Months				Spacing Measure: Gap < 2 Years			
	PIAT-Math		PIAT-Read-Cog		PIAT-Math		PIAT-Read-Cog	
Sample:	[1]	[2]	[1]	[2]	[1]	[2]	[1]	[2]
All	-0.0018**	-0.0016*	-0.0005	-0.0017*	-0.1296**	-0.0432	-0.0516	0.0374
	(0.0007)	(0.0009)	(0.0008)	(0.0009)	(0.0440)	(0.0413)	(0.0448)	(0.0424)
	4,049	3,880	4,048	3,881	4,049	3,880	4,048	3,881
High AFQT	-0.0038**	-0.0032**	-0.0015	-0.0024*	-0.0012	0.0127	0.0474	0.0791
	(0.0010)	(0.0013)	(0.0010)	(0.0013)	(0.0619)	(0.0578)	(0.0630)	(0.0606)
	1,881	1,881	1,882	1,882	1,881	1,881	1,882	1,882
Low AFQT	0.0014	0.0006	0.0005	-0.0010	-0.1499**	-0.0306	-0.0299	0.0772
	(0.0010)	(0.0012)	(0.0009)	(0.0012)	(0.0607)	(0.0613)	(0.0597)	(0.0641)
	1,936	1,855	1,938	1,858	1,936	1,855	1,938	1,858
High Family Income	-0.0034**	-0.0038**	-0.0006	-0.0024*	-0.1069*	-0.0584	-0.0499	0.0086
	(0.0011)	(0.0013)	(0.0012)	(0.0013)	(0.0599)	(0.0576)	(0.0595)	(0.0570)
	1,893	1,828	1,890	1,826	1,893	1,828	1,890	1,826
Low Family Income	0.0020**	0.0006	0.0013	-0.0004	-0.2219**	-0.1309**	-0.1265**	-0.0335**
	(0.0009)	(0.0011)	(0.0009)	(0.0010)	(0.0511)	(0.0536)	(0.0568)	(0.0485)
	1,999	1,999	1,999	1,999	1,999	1,999	1,999	1,999
Additional Controls		x		x		x		x
Year of Birth Dummies		x		x		x		x

**, * Denote signifigance at 5% and 10% respectively. Each entry is from a separate regression and gives the coefficient on spacing, in months, for the indicated sample and specification. Each observation is a sibling pair, and child weights are used. Additional controls include child gender and mother's race, age at first birth, education, number of children, marital status at first birth, and AFQT score. See text for definitions of AFQT and income categories. Test scores are age-adjusted and standardized. Standard errors are clustered by mother and are in parenthesis; number of observations is given below the standard error. Sample is restricted to intervals less than 10 years.

Table 5: OLS Estimates of Effect of Spacing on Test Scores, by Characteristics

Panel A: Older Siblings

	Spacing Measure: Gap in Months		Spacing Measure: Gap < 2 Years	
Sample:	PIAT-Math	PIAT-Reading	PIAT-Math	PIAT-Reading
High Birth Order[a]	0.0022**	0.0026**	-0.1218**	-0.1734**
	(0.0009)	(0.0010)	(0.0507)	(0.0487)
	2,874	2,868	2,874	2,868
Low Birth Order[a]	0.0017	-0.0006	-0.1679**	0.0415
	(0.0011)	(0.0010)	(0.0674)	(0.0692)
	1,343	1,344	1,343	1,344
Boys	0.0019**	0.0014	-0.1213**	-0.0454
	(0.0010)	(0.0010)	(0.0598)	(0.0621)
	2,143	2,143	2,143	2,143
Girls	0.0019**	0.0010	-0.1572**	-0.1491**
	(0.0009)	(0.0010)	(0.0555)	(0.0539)
	2,074	2,069	2,074	2,069

Panel B: Younger Siblings

	Spacing Measure: Gap in Months		Spacing Measure: Gap < 2 Years	
Sample:	PIAT-Math	PIAT-Reading	PIAT-Math	PIAT-Reading
High Birth Order[a]	-0.0021*	-0.0016	-0.0686	0.0060
	(0.0012)	(0.0011)	(0.0524)	(0.0478)
	2,652	2,653	2,533	2,534
Low Birth Order[a]	-0.0013	-0.0012	0.0068	0.0989
	(0.0014)	(0.0014)	(0.0668)	(0.0752)
	1,228	1,228	1,149	1,149
Boys	-0.0013	-0.0016	-0.081	0.0191
	(0.0012)	(0.0011)	(0.0567)	(0.0616)
	2,034	2,036	1,932	1,934
Girls	-0.0010	-0.0002	-0.0132	0.0391
	(0.0012)	(0.0012)	(0.0563)	(0.0551)
	1,846	1,845	1,750	1,749

[a] Since samples include sibling pairs for first- and second-born children and for second- and third-born children, "high birth order" refers to first-born children for the older sample and to second-born children for the younger sample. Low birth order refers to second- and third born children, respectively.

**, * Denote signifigance at 5% and 10% respectively. Each entry is from a separate regression and gives the coefficient on spacing, in months, for the indicated sample and specification. Each observation is a sibling pair, and child weights are used. Additional controls include child gender and mother's race, age at first birth, education, number of children, marital status at first birth, and AFQT score. Test scores are age-adjusted and standardized. Standard errors are clustered by mother and are in parenthesis; number of observations is given below the standard error. Sample is restricted to intervals less than 10 years.

Table 6: Marginal Effects from Probit Regression of Miscarriage Between Siblings on Pre-Characteristics

	All	High AFQT	Low AFQT	High Income	Low Income
Older Child is Female	-0.0201**	-0.0225*	-0.0110	-0.0241*	-0.0167
	(0.0093)	(0.0125)	(0.0127)	(0.0131)	(0.0126)
Hispanic	-0.0093	-0.0047	-0.0043	0.0242	-0.0287*
	(0.0115)	(0.0189)	(0.0149)	(0.0199)	(0.0136)
Black	-0.0282**	-0.0277	-0.0254	-0.0282	-0.0369**
	(0.0106)	(0.0162)	(0.0156)	(0.0161)	(0.0144)
Age at First birth	0.0000	0.0000	-0.0001	0.0000	0.0001*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Age at First Birth^2	0.0000	0.0000	0.0000*	0.0000	-0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Gap 1-2	0.0297**	0.0373**	0.0165	0.0213	0.0458**
	(0.0098)	(0.0129)	(0.0137)	(0.0143)	(0.0116)
Married at First Birth	-0.0060	-0.0223	0.0075	0.0096	-0.0092
	(0.0124)	(0.0207)	(0.0144)	(0.0175)	(0.0159)
High School Degree	-0.0083	-0.0206	-0.0011	0.0088	-0.0267*
	(0.0124)	(0.0218)	(0.0141)	(0.0209)	(0.0162)
College Degree	-0.0280	-0.0370	-0.0149	-0.0308	-0.0093
	(0.0160)	(0.0215)	(0.0387)	(0.0242)	(0.0294)
AFQT	0.0001	0.0000	0.0007	0.0001	0.0002
	(0.0002)	(0.0003)	(0.0008)	(0.0003)	(0.0003)
Older Child's Birth Weight	-0.0002	0.0003	-0.0008**	0.0000	-0.0006*
(ounces)	(0.0002)	(0.0004)	(0.0003)	(0.0003)	(0.0003)
Observations	4,386	2,178	2,208	1,996	2,063
Pseudo R-squared	0.0156	0.0228	0.0196	0.0227	0.0479
Mean Miscarriages	0.0671	0.0691	0.0653	0.0680	0.0653
Std. Dev.	0.2503	0.2536	0.2472	0.2518	0.2471

**, * Denote signifigance at 5% and 10% respectively. Each column is a separate regression where the dependent variable is equal to one if the mother miscarried between the births and zero otherwise. Each observation is a sibling pair, and child weights are used. See text for definitions of AFQT and income categories. Standard errors are clustered by mother and are in parenthesis. Sample is restricted to intervals less than 10 years.

Table 7: First Stage Estimates of Effect of Miscarriage on Spacing

	Spacing Measure: Gap in Months		Spacing Measure: Gap < 2 Years	
Sample:	Older Siblings	Younger Siblings	Older Siblings	Younger Siblings
All	9.9501**	7.8226**	-0.1768**	-0.1403**
	(1.6037)	(1.5032)	(0.0228)	(0.0238)
	[38.49]	[27.08]	[60.28]	[34.72]
High AFQT	9.1776**	7.7132**	-0.1693**	-0.1278**
	(1.9789)	(1.8320)	(0.0286)	(0.0297)
	[21.51]	[17.73]	[35.08]	[18.51]
Low AFQT	11.2324**	9.4804**	-0.1864**	-0.1793**
	(2.8414)	(2.2649)	(0.0353)	(0.0382)
	[15.63]	[17.52]	[27.89]	[22.09]
High Family Income	8.8967**	7.8424**	-0.1326**	-0.0954**
	(2.1592)	(2.1249)	(0.0347)	(0.0361)
	[16.98]	[13.62]	[14.63]	[6.97]
Low Family Income	11.8293**	9.0608**	-0.2017**	-0.1822**
	(2.7124)	(2.1534)	(0.0328)	(0.0343)
	[19.02]	[17.7]	[37.85]	[28.19]

**, * Denote signifigance at 5% and 10% respectively. Each entry is from a separate regression and gives the coefficient on the indicator for miscarriage, for the indicated sample and specification. The dependent variable is spacing in months or a dummy variable equal to one for gaps less than two years. Each observation is a sibling pair, and child weights are used. Additional controls include child gender and mother's race, age, education, number of children, marital status, and AFQT score. See text for definitions of AFQT and income categories. Standard errors are clustered by mother and are in parenthesis; F-statistics are reported below the standard error. Sample is restricted to intervals less than 10 years.

Table 8: Instrumental Variables Estimates of Effect of Spacing on Test Scores

Panel A: Older Siblings

	Spacing Measure: Gap in Months		Spacing Measure: Gap < 2 Years	
Sample:	PIAT-Math	PIAT-Reading	PIAT-Math	PIAT-Reading
All	0.0082	0.0101	-0.4699	-0.5775
	(0.0079)	(0.0072)	(0.4453)	(0.3928)
High AFQT	0.0048	0.0056	-0.2530	-0.2920
	(0.0117)	(0.0108)	(0.6039)	(0.5482)
Low AFQT	0.0076	0.0181*	-0.4518	-1.0827**
	(0.0101)	(0.0101)	(0.5980)	(0.5365)
High Family Income	0.0093	0.0004	-0.6082	-0.023
	(0.0127)	(0.0105)	(0.8145)	(0.6836)
Low Family Income	0.0142*	0.0129*	-0.9538*	-0.8718*
	(0.0083)	(0.0078)	(0.5414)	(0.5139)

Panel B: Younger Siblings

	Spacing Measure: Gap in Months		Spacing Measure: Gap < 2 Years	
Sample:	PIAT-Math	PIAT-Reading	PIAT-Math	PIAT-Reading
All	-0.0038	0.0036	0.2263	-0.2175
	(0.0083)	(0.0095)	(0.5021)	(0.5686)
High AFQT	-0.0074	0.0052	0.4634	-0.3220
	(0.0116)	(0.0134)	(0.7363)	(0.8358)
Low AFQT	-0.0030	0.0028	0.1614	-0.1517
	(0.0112)	(0.0132)	(0.6060)	(0.7201)
High Family Income	-0.0073	0.0041	0.6299	-0.355
	(0.0107)	(0.0121)	(0.9618)	(1.0596)
Low Family Income	0.0058	0.0013	-0.3381	-0.0789
	(0.0106)	(0.0090)	(0.6152)	(0.5294)

**, * Denote signifigance at 5% and 10% respectively. Each entry is from a separate regression and gives the coefficient on spacing, in months, where miscarriage is used as an instrument for spacing. The dependent variable is the age-adjusted, standardized test score. Each observation is a sibling pair, and child weights are used. Additional controls include child gender and mother's race, age at first birth, education, number of children, marital status at first birth, AFQT score, and an indicator for high family income. See text for definitions of AFQT and income categories. Standard errors are clustered by mother and are in parenthesis. Sample is restricted to intervals less than 10 years.

Table 9: IV Estimates of Effect of Spacing on Test Scores, for Low-Income

Panel A: Older Siblings

	Spacing Measure: Gap in Months		Spacing Measure: Gap < 2 Years	
Sample:	PIAT-Math	PIAT-Reading	PIAT-Math	PIAT-Reading
High Birth Order[a]	0.0098	0.0275*	-0.4040	-1.1385**
	(0.0147)	(0.0152)	(0.5982)	(0.5283)
	1,365	1,362	1,365	1,362
Low Birth Order[a]	0.0043	-0.0022	-1.0129	0.4900
	(0.0079)	(0.0055)	(2.0046)	(1.2241)
	628	629	628	629
Boys	-0.0079	0.0089	0.4191	-0.4694
	(0.0186)	(0.0137)	(0.9524)	(0.7131)
	994	994	994	994
Girls	0.0187	0.0253	-1.1594	-1.5717**
	(0.0138)	(0.0155)	(0.7187)	(0.7539)
	999	997	999	997

Panel B: Younger Siblings

	Spacing Measure: Gap in Months		Spacing Measure: Gap < 2 Years	
Sample:	PIAT-Math	PIAT-Reading	PIAT-Math	PIAT-Reading
High Birth Order[a]	0.0018	0.0001	-0.0746	-0.0036
	(0.0128)	(0.0135)	(0.5232)	(0.5461)
	1,257	1,260	1,257	1,260
Low Birth Order[a]	-0.0044	0.0161	1.5073	-5.4327
	(0.0131)	(0.0308)	(4.0002)	(20.0488)
	576	576	576	576
Boys	0.0034	0.0245	-0.1921	-1.3826
	(0.0199)	(0.0319)	(1.1527)	(1.8826)
	945	948	945	948
Girls	0.0000	-0.0011	0.0019	0.0598
	(0.0130)	(0.0145)	(0.6852)	(0.7655)
	888	888	888	888

[a] Since samples include sibling pairs for first- and second-born children and for second- and third-born children, "high birth order" refers to first-born children for the older sample and to second-born children for the younger sample. Low birth order refers to second- and third born children, respectively.

**, * Denote signifigance at 5% and 10% respectively. Each entry is from a separate regression and gives the coefficient on spacing, in months, and on a dummy variable equal to one for spacing less than two years for the indicated sample and specification. Each observation is a sibling pair, and child weights are used. Additional controls include child gender and mother's race, age at first birth, education, number of children, marital status at first birth, and AFQT score. Test scores are age-adjusted and standardized. Standard errors are clustered by mother and are in parenthesis; number of observations is given below the standard error. Sample is restricted to intervals less than 10 years.