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ABSTRACT

After roughly 10 years of decline, the U.S. fertility rate reached a historic low in 2017. However, aggregate trends in fertility mask substantial heterogeneity across different demographic groups. Young women and unmarried women have seen the largest declines in fertility in recent years while women older than 30 and married women have actually experienced increases. In this paper, we explore the role of changes in unintended births in explaining fertility patterns in the U.S. from 1980 to 2017, with an emphasis on the fertility decline of the last decade. We begin by documenting heterogeneity in fertility trends across demographic groups, using data from the National Center for Health Statistics' Natality Detail Files. We then use data from the National Survey of Family Growth to describe trends in unintended births and to estimate a model that will identify the maternal characteristics that most strongly predict them. Finally, we use this model to predict the proportion of births in the Natality Detail Files that are unintended. We find that 35% of the decline in fertility between 2007 and 2016 can be explained by declines in births that were likely unintended, and that this is driven by drops in births to young women.

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I. Introduction

Birth rates in the United States are at historic lows. The provisional general fertility rate for 2017 was less than half of what it was at the peak of the baby boom, and the total fertility rate remains well below replacement level (Hamilton et al. 2018).[1] These low fertility levels are the result of a dramatic decline in the last decade, as the birth rate has fallen thirteen percent since 2007 (see Figure 1). This trend has received significant attention in the popular press, with articles trying to understand both the underlying causes and the implications for policy and economic growth (Belluz 2018; The Economist 2018; Howard 2019; Miller 2018;). However, aggregate trends in fertility mask substantial heterogeneity across different demographic groups. For example, the decline in birth rates since 2007 was driven by women under age thirty; for women over thirty, birth rates actually increased over this period. Looking back further, birth rates for women over thirty have been steadily increasing since at least 1980, while the rate for younger women (and especially teens) peaked in the early 1990s. Trends in birth rates also differ by marital status; from 1980 to the mid-2000s, rates for married and unmarried women were converging as the nonmarital childbearing rate rose. Since then, the rate for unmarried women has started to decline, while that for married women has increased.

Importantly, the groups that have seen the largest declines in fertility in recent years—young women and unmarried women—are the groups that have historically been most likely to have *unintended* births. Definitions of intendedness vary, but generally a birth is considered to be unintended if either the pregnancy was unwanted or it occurred earlier than the mother would have liked. Research using the National Survey of Family Growth (NSFG) shows that the share of

[1] The birth rate (or general fertility rate) in 2017 was 60.2 births per 1,000 women age 15 to 44. The total fertility rate, which measures "the number of births that a hypothetical group of 1,000 women would have over their lifetimes, based on the age-specific birth rates in a given year," was 1764.5 (Hamilton et al. 2018). Replacement-level total fertility is 2,100.

pregnancies that were unintended was relatively constant over the 1980s and 1990s (Mosher et al. 2012), increased between 2001 and 2008 (Finer & Zolna 2011, 2014), and then decreased dramatically between 2008-2011 (Finer & Zolna 2016). However, one challenge in this literature is that the data sets that have measures of intendedness have relatively small sample sizes. Furthermore, the NSFG does not survey women every year prior to 2006, making it difficult to create consistent trends over time.[2]

A better understanding of how unintended births are changing over time could have significant policy implications. Unintended pregnancies are associated with lower levels of prenatal care (Kost and Lindberg 2015), and births from unintended pregnancies are more likely to have low birth weight (< 2500 grams) and to experience costly complications (Kost & Lindberg 2015; Mohllajee et al. 2007). Over two-thirds of unintended births in 2010 were paid for by public insurance programs, costing the government over $21 billion in that year (Sonfield & Kost 2015). Unwanted and mistimed births are also associated with worse child health and development outcomes (Hummer et al. 2004; Lin et al. 2018).[3] So, while a falling fertility rate presents challenges for (for example) the solvency of public pension programs, there may be cost savings if the decline is coming from unintended births.[4] Policy makers who are concerned about fertility declines may therefore want to focus on strategies for increasing *intended* births.

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[2] Other data sets that include these measures, including the Pregnancy Risk Assessment Monitoring System (PRAMS) and the Panel Study of Income Dynamics (PSID) have similar issues. See Section III for a more detailed discussion of definitions and measures of unintended births.

[3] Establishing a causal relationship between wantedness and later outcomes is difficult due to the potential for omitted variables bias. Adding controls for parental characteristics typically attenuates the estimated correlation coefficient but a significant relationship often remains (Hummer et al. 2004).

[4] As fertility drops, there will be fewer working age individuals to support the elder (age 65+) dependent population, which leads to quicker depletion of the Social Security Trust Fund. Nearly all of the expected increase in Social Security program costs from 2010 to 2030 is projected to be due to the increasing aged dependency ratio (Goss 2010). The recent fertility declines will likely put further strain on the system.

In this paper, we explore the role of changes in unintended births in explaining fertility patterns in the U.S. from 1980 to 2017, with an emphasis on the fertility decline of the last ten years. To do this, we begin by documenting heterogeneity in fertility trends across demographic groups, using data from the National Center for Health Statistics' (NCHS) Natality Detail Files.[5] We then use data from the NSFG to describe trends in unintended births and to estimate a model that will identify the maternal characteristics that most strongly predict them. Finally, we use this model to predict the proportion of births in the Natality Detail Files that are unintended. This allows us to create trends in likely unintended births using a measure that is consistent over time, and to determine how changes in the predicted proportion of births that are unintended are related to changes in the underlying characteristics of new mothers.

We contribute to the literatures on fertility trends and unintended births in three ways. First, the method we develop allows us to determine the proportion of the roughly four million births in the Natality Detail Files that are unintended each year that is consistent over time. This addresses several challenges with using the NSFG and similar data sets for this purpose. Furthermore, because many data sets do not contain information on intendedness, our method can be used by future researchers when studying intendedness using datasets without direct measures. Second, we show how changes in unintended births have contributed to fertility trends in the U.S. over the last several decades. Third, we show that changes over time in the proportion of births that are likely unintended are largely due to changes in which women are giving birth, and isolate the effect of specific demographic changes on unintended births over time. We find that 35% of the fertility decline of the last ten years can be explained by fewer births to women whose births were likely to

[5] The Natality Detail Files provide information obtained from each birth certificate issued in the United States. States provide their birth certificate data to the NCHS, which compiles the data. There is some variation across states and over time in the information that is available from the birth certificates; we discuss this below where it is relevant.

be unintended, and specifically by declines in births to young women. The downward trend in births over the last decade of economic recovery has puzzled demographers, and our findings show that understanding the changes driving the declines in unintended births over the period could be a key part of solving this puzzle.

II. Trends in Fertility

Between 1900 and 2017, the U.S. general fertility rate fell by more than half (130 to 60.2 births per 1000 women aged 15 to 44). This decline has been non-monotonic; the rate fell to 76.3 in 1933 before rising to 122.9 in 1957 during the peak of the baby boom. An extensive literature explores the root causes of the baby boom and subsequent bust (see Bailey, et al. 2014, and Bailey & Hershbein 2018 for reviews). In short, the causes can be split into changes in demand (due to changes in preferences or income) and changes in supply (due to the development of reproductive technologies or changes in access to these technologies). Literature examining the post-1960 decline has suggested that the birth control pill (approved by the FDA for use as a contraceptive in 1960) and legal access to abortion (beginning in 1969) are key drivers of the post-1960 decline in births (Bailey 2006; Bailey 2010; Bailey et al. 2013 a,b; Goldin and Katz 2002; Guldi 2008; Myers 2017). The Vietnam War also played a role in declining birth rates over the 1960s (Bitler & Schmidt 2011). Since the early 1970s, the decline has been smoother and comparatively flat (Bailey et al. 2014). However, as we demonstrate in Figure 1, the period since 1980 continues to exhibit a fair degree of volatility and contains two local peaks: 1990 and 2007. [6] The post-2007 decline produced a general fertility rate that is at its lowest level in all of recorded U.S. history.

[6] In Figures 1 and 2, we calculate birth rates as the number of births per 1,000 women in the indicated age group. The numerators are from the Natality Detail Files, and the age- and sex-specific population counts used in the denominators are taken from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER). The SEER population counts are

As we discussed in the introduction, these aggregate trends in fertility conceal big differences in how fertility is changing for women with different characteristics. An important example is age. There has been a widely-documented decline in the birth rate for teenagers in the U.S. since the early 1990s, which has been attributed to a variety of supply and demand factors including but not limited to: more affordable contraception via Medicaid (Kearney & Levine 2009, 2015a) or access to more reliable long-acting and reversible methods of contraception like IUDs (Lindo & Packham 2017); changes in income inequality, with areas with lower income inequality experiencing lower levels of teen births (Kearney & Levine 2014); and the effect of new media (targeted television programming, social media, and the Internet) on teen fertility choices (Guldi & Herbst 2017; Kearney & Levine 2015b; Trudeau 2016).[7]

The decline in the fertility of younger women is evident in Figure 2, which reports birth rates by five-year age groups from 1980 to 2017. The teen birth rate fell from a peak of around 62 births per 1,000 women age 15 to 19 in 1991, to around 19 in 2017, for a remarkable 69 percent decline. The birth rate for women 20 to 24 also declined over this same period, with the decline accelerating in 2008. While this group had the highest birth rate in 1980, it now has a rate that is below that for women 25 to 29 and even 30 to 34. Conversely, birth rates for women over 30 have increased steadily since 1980, aided by a delayed age at first marriage and first birth and infertility treatments that have facilitated births at later ages (Buckles 2007; Matthews & Hamilton 2009, 2016; Schmidt 2007; U.S. Census Bureau 2018). For the first time in US history, the age group with the highest birth rate in 2016 was women 30 to 34.

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not yet available for 2017, so for that year we use birth rates from the NCHS provisional births data for 2017 (Hamilton et al. 2018).

[7] While the literature primarily examines the effects of these factors on teen birth rates, many of them may also have affected fertility choices of older women. For example, Kearney and Levine (2009) show that the likelihood of birth declines for both teens and older women when access to publicly funded contraception increases.

There have also been significant changes in the marital status of women giving birth over this period. Figure 3 shows the birth rate for married and unmarried women from 1980 to 2016, where we use population estimates by marital status from the Current Population Survey Annual Social and Economic Supplement (CPS-ASEC) in the denominator.[8] The birth rate for married women fell throughout the 1980s and early 1990s, while that for unmarried women rose, so that by 1994 approximately one-third of births were to an unmarried mother (see also Curtin et al. 2014). The nonmarital rate stabilized for a few years after that, but began to increase again in the mid-2000s, reaching a peak in 2007. Since then, the nonmarital rate has declined, while births to married women have actually increased. The decline in fertility over the last decade is therefore not driven by a decline among married women.

We show the combined effect of changes in mothers' age and marital status in Figure 4. Here, rather than showing trends by the infant's year of birth, we present results by the mother's birth year in order to show how nonmarital childbearing at different ages varies by cohort. Each line in the figure shows the average number of unmarried births that women in each birth cohort had by the indicated age. To construct the data points, we first calculate the mother's birth year by subtracting the mother's age at birth from the infant's year of birth.[9] We then add the number of total nonmarital births to women born in that year before that age, and divide by the size of that year's birth cohort, taken from the SEER single-year-of-age and gender population counts for the year the birth cohort turned 15. For example, women born in 1964 had 0.3 children out of wedlock by age 25, on average. This number was higher for subsequent cohorts, leveling off at around 0.8 for

[8] We are not able to include 2017 in the figure because due to statutory restrictions, California no longer reports marital status in the birth certificate data it reports to the NCHS after 2016. About twelve percent of births in the U.S. are in California.

[9] More precisely, mother's birth year is estimated as the infant's birth year minus the mother's age for July-December births (as most women giving birth in those months would already have had their birthday that year), and the infant's birth year minus the mother's age minus one for January-June births.

women born in the late 1970s. Looking at the number born before age 45 gives a picture of near-complete fertility for a cohort, though this can only be calculated for cohorts born before 1974. Nevertheless, we see that the average number of children born outside of marriage rose between the 1965 and 1973 cohorts. The decline in nonmarital childbearing of the last few years is driven by more recent cohorts—those born in the late 1980s and early 1990s had fewer nonmarital births by age 25 than their predecessors. The 1976 birth cohort had the most out-of-wedlock teen births, with nearly one such birth per every five women. For the 1998 birth cohort (the most recent with completed teenage childbearing), that number is one per every 13.4.

We are not able to use the Natality Detail Files to produce consistent trends by mothers' education in the same way that we have done for age and marital status.[10] However, research using other data sources has shown that there are also important differences in fertility trends by educational attainment. Average age at first birth is higher for high-education women and average completed fertility is higher for low-education women. Additionally, the difference between low- and high-education mothers' completed fertility is not stable over time, with the smallest difference occurring with the most recent cohorts, suggesting some convergence (Bailey et al. 2014).

Finally, we show trends in births by race, Hispanic ethnicity, and parity in Appendix Figure 2.[11] Relative to the trends for age and marital status, trends in race and parity are stable from 1980-2017, though the number of births to white women and nulliparous women has dropped since 2007. Hispanic ethnicity is not reported by all states in their birth certificate data prior to 1989, so we are

[10] Maternal education is not collected the same way for every state for every year in our sample and this leads to considerable measurement error. Furthermore, revisions to the standard birth certificate in 1989 and 2003 included changes in the education variable, leading to seaming issues. We did explore the role of education in Appendix Figure 1. The trends over the past ten years suggest decreases in births to women with the lowest levels of education and increases in births to more educated women, a pattern that is similar to the ones we see by age and marital status.

[11] We show the number of births in each group rather than a group-specific birth rate in Appendix Figure 2 because the population used in the denominator is either not well-defined (in the case of parity) or is measured inconsistently over time (in the case of race and ethnicity).

only able to construct our combined race and ethnicity series from that point forward; for this period we see that the number of births to Hispanic women doubled between 1989 and 2007 but has declined since. We include these characteristics in our analysis of unintended births described in the next section, and discuss the role of births to Hispanic women in particular in the results section.

III. Unintended Births

The fertility decline since 2007 in the U.S. is driven by births to young and unmarried women, suggesting a role for unintended births, as these women have historically been most likely to experience unintended pregnancies (Finer & Zolna 2014; Kost & Lindberg 2015). Indeed, Finer and Zolna (2016) identified a decrease in the unintended pregnancy rate between 2008 and 2011, driven by declines among young and poor women.[12] They report that this was the first "substantial decline" since 1981. This decrease is also documented in Finer et al. (forthcoming), using the same data but a prospective instead of retrospective measure of unintended pregnancies.[13]

We begin our investigation of the role of unintended births in explaining fertility trends by using the NSFG to construct a time series of the fraction of births that are unintended over time. Because our aim is to describe the role of pregnancy intention in explaining trends in *realized* births, our analysis is restricted to pregnancies that ended in a live birth. Measures of intendedness vary with the survey used, whether the focus is solely on pregnancy intention or also birth intention, and whether the measure incorporates information about the intended timing. Guzzo (2017a) use questions on pregnancy wantedness and timing from the NSFG to classify births as 1) unwanted (individual did not want any births or any additional births); 2) seriously mistimed (wanted but

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[12] They define the unintended pregnancy rate as the number of unintended pregnancies per 1,000 women age 15 to 44. Data are from the NSFG.
[13] Kost et al. (2018) present state-level estimates of unintended pregnancies from the 2014 PRAMS, but due to a change in the questions asked, they state that these measures are not comparable to estimates from earlier years.

occurring more than two years earlier than desired); 3) slightly mistimed (wanted but occurring less than two years earlier than desired); and 4) wanted and on-time. Guzzo et al. (2018) show that the two-year cutoff is a meaningful threshold for defining pregnancy intention. More recently, Guzzo et al. (2018) offer new ways to think about how fertility is classified as unintended using survey data and this research highlights that both short- and long- run factors are important to the individual when evaluating intendedness.

For our analysis, we construct a measure of unintended births that is similar in spirit to that used in Guzzo (2017a) that combines responses to two questions in the NSFG Pregnancy Files. The first asks women "if you had to rate how much you wanted or didn't want a pregnancy right before you got pregnant that time, how would you rate yourself?"[14] Respondents are asked to use a 0 to 10 scale, where zero indicates that the woman wanted to avoid the pregnancy and 10 indicates that she wanted to get pregnant. We classify a birth as unintended if the response was below five. The NSFG also asks whether the birth occurred sooner than the woman intended, and if so, by how much. Following Guzzo et al. (2018), we further define a birth as unintended if the woman says that it was wanted but was too soon by two years or more. Using this definition, over 35 percent births in our sample in 2005-06 were unintended.[15,16] We combine the concepts of wantedness and timing into a single binary variable because we also plan to use this measure as the dependent variable in a linear probability model that predicts unintended births in the population.

[14] Measures of wantedness have some well-known drawbacks. Rosenzweig and Wolpin (1993) find a great deal of ex post rationalization in self-reports of wantedness based on post-birth outcomes. Mosher et al. (2012) and Campbell and Mosher (2000) provide additional discussion of measurement issues.

[15] This is similar to the share of births reported by Mosher et al. (2012) as unintended. They use a slightly different sample constructed using the 2006-2010 NSFG and report that 37% of births are unintended.

[16] All analysis uses the NSFG final weights to produce a sample that is more representative of the U.S. population.

The time trend for unintended births using this measure is shown in Figure 5. To construct the figure, we combine the data from the 2002, 2006-10, 2011-13, and 2013-15 NSFG cycles. In order to maintain a comparable age profile over time, we also restrict the sample to women who were age 15 to 42 at the time of the birth, and to births that occurred within three years of the survey date.[17] This leaves us with a sample of nearly 8,000 births that occurred between 1999 and 2015. We then collapse the data into two-year bins by the year of birth (or three-year in the case of 2013-15).

Using this definition of intention (the solid line), it appears that unintended births peaked in 2005-06, when 35.6% of births were unintended. Since then, the fraction unintended has declined steadily, reaching 29.5% for 2013-15 births, for a 17 percent decline. Our data also show the decline that Finer and Zolna (2016) observe for unintended pregnancies between 2008 and 2011.

The other trend lines in Figure 5 show results for alternative measures of pregnancy intention. These measures use the NSFG questions asking respondents how happy they were to learn that they were pregnant, whether they were trying to become pregnant immediately before conception, and the question about wantedness alone. All three alternative measures are highly correlated with our primary measure of intention, with correlation coefficients of 0.57, 0.67, and 0.88, respectively. This correlation is evident in Figure 5, which shows that these other measures move closely with our preferred measure. We have also confirmed that the conclusions of our analysis below are robust to using these alternative measures.

While Figure 5 gives a general sense of the overall trends in unintended births, there are issues that make it difficult to use the NSFG for this purpose despite its carefully crafted questions about

[17] Including women with births further in the past would introduce selection bias, as we would be over-sampling women who were relatively young at the time of birth (a women who gives birth at 25 can have it appear in her retrospective birth history in the NSFG for 20 more years, until age 45, while a woman who gives birth at 40 can only appear for 5 more years). Once we impose this restriction, we drop the few women with births at ages 43 to 45. This is because we would not be able to observe births at these ages for many women whose births were one to three years before the NSFG interview year, as they would have aged out of the NSFG sampling frame.

pregnancy wantedness and timing. First, after limiting the sample as described above to be able to maintain a constant age profile over time, there are only about 8,000 births in Figure 5, or fewer than 1,000 births per data point. The sample size is not constant over time, with 1,303 births for 2011-12 but only 461 for 2003-04 (a period that shows a large dip in unintendedness). Second, questions about pregnancy intentions are asked retrospectively for the births in our sample, which may introduce recall bias in responses (Rosenzweig & Wolpin 1993). Since NSFG cycles are administered at irregular intervals as many as four years apart, the degree of this bias may not be constant over time. Third, while we use standard weighting procedures described in the 2013-2015 NSFG User's Guide[18] to attempt to create a sample that is representative of the US population over time, the guide itself warns that "one should be cautious when interpreting estimates from combined data files because the NSFG has not been conducted with a continuous nor annual survey design that would permit valid estimation and inference for the full span of years" (p. 7).

To demonstrate the severity of these issues, we create trends for characteristics that are observable in both the NSFG and in the Natality Detail Files, where the latter represents the true population. The sample is the same as that used in Figure 5. As is illustrated in Figure 6, even for well-measured characteristics like age at birth and marital status, the NSFG trends are much noisier than those from the Natality data, and do not accurately capture the population trends.

We address these issues by using the NSFG to construct a model of pregnancy intention that we can use to predict the fraction of births in the Natality Detail Files that are likely to be unintended. We model birth intendedness as a function of the mother's age and marital status at birth. Birth intendedness has also been shown to vary by race and ethnicity as well as educational attainment (Guzzo 2017b; Hayford and Guzzo 2016), so we include these maternal characteristics in

[18] Available at https://www.cdc.gov/nchs/data/nsfg/NSFG_2013-2015_UG_App2_FileManipulations_rev.pdf

our model, along with other measures meant to capture the mother's socioeconomic status and background. We estimate the following model:

$$Unintended_i^{\,k} = a + X_i^{\,k}\beta + Z_i^{\,k}\lambda + \varepsilon_i \qquad (1)$$

$Unintended_i^{\,k}$ is a binary variable indicating that birth i in NSFG cycle k (2002, 2006-2010, 2011-2013, or 2013-2015) was unintended using our preferred measure as defined above. $X_i^{\,k}$ is a vector of maternal characteristics that are common to both the NSFG and the Natality Detail Files, including age at birth categories (over 30 is the omitted group), indicators for race (white is the omitted group), parity, and an indicator for being married at the time of the birth. $Z_i^{\,k}$ is a vector of characteristics that are either unique to the NSFG or are not consistently measured in the Natality Detail Files, including measures of the mother's education, poverty status, and religiosity. The distinction between variables that are and are not available in the Natality Detail Files will be important in the next section, when we use this model to predict unintended births in the population. We estimate heteroskedasticity-robust standard errors.

The results from estimating Equation (1) for each of four NSFG cycles are in Table 1. Conditional on the other variables in the model, the characteristics that most strongly predict that a birth was unintended across the four cycles are being a teenager and being unmarried at birth. For example, in 2002, women who were teenagers at the time of the birth were 37 percentage points more likely to have a birth that was unintended, *ceteris paribus*, relative to a mean of 32.6. Other characteristics that are consistently associated with an unintended birth are higher parity and poverty status. While the level of statistical significance varies across the four cycles for some of the variables, the models consistently reveal that women with lower socio-economic status are more likely to have unintended births.

We now use our model from Equation (1) to predict the proportion of births in each year that were unintended. To do this, we modify Equation (1) to include only those variables that are common to both the NSFG and the Natality Detail Files and that are measured consistently over time (the X_i). We also use single-year-of-age dummies and separate dummies for each parity from one to nine-plus to increase the model's predictive power. We use the model from the 2002 cycle of the NSFG, which includes 2,050 births to women age 15 to 44 between 1999 and 2002. The coefficients from this model give us the "return" to each characteristic in the 2002 NSFG. The full set of coefficients from this model is available in Appendix Table 1, and the R-squared from the model is 0.2447. We choose the 2002 cycle as our "index" year because it is at the midpoint of our period of interest, but our conclusions are not affected by using other years as the index year, as we discuss in our results section. This robustness is a result of the fact that the coefficients (and therefore, the return to the characteristics) are quite stable across the different cycles.[19]

Next, in the Natality Detail Files, we calculate the average value of each right-hand side variable (the X's) for women giving birth in each year between 1980 and 2016.[20] Finally, we multiply each year's X values by the β coefficients from Appendix Table 1. The result is the predicted fraction of births that were unintended in each year, based on the characteristics of women giving birth in that year and holding the "returns" to each characteristic constant at the 2002 level. This approach is similar to that developed by Baicker et al. (2006) to create a predicted probability of Caesarean birth, and used in Buckles and Guldi (2017) to understand the contribution of demographic changes to trends in preterm birth.

IV. Results

The results of this exercise are reported in Figure 7, which shows how the predicted proportion

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[19] Appendix Table 2 shows estimates from a more parsimonious version of our prediction model for easier comparison of the coefficients across the four cycles.

[20] Here again we are not able to include 2017 in our analysis because California no longer reports marital status in its birth certificate data after 2016.

of births that are unintended (PPU) evolved between 1980 and 2016. We observe four distinct periods. First, after reaching a low in 1985 at 0.353, the PPU increased significantly through the mid- and late 1980s. Second, the PPU was very stable from 1991 to 2003, at around 0.37. Third, the PPU began to increase again in 2004, reaching a peak in 2008 when we predict that 37.8% of births were unintended. Fourth, since 2008, the PPU has declined steadily, reaching 34.7%.

Comparing the trends in Figure 7 to those in Figure 1, it appears that the drop in the PPU coincides with the overall drop in fertility since 2007, suggesting that declines in unintended births were an important factor. To estimate how much of a fertility change can be explained by the PPU, we take peaks and troughs in the number of total births, and then examine the time periods between them. For a given time period (for example, between 1990-1997 or between 2007-2016), we hold the total number of births constant at the initial year, and apply the PPU for both the initial year and the final year to see what change in unintended births would be implied only by the change in the PPU, holding the total number of births constant. We then calculate the share of the change in total births during that time period that would be accounted for by the predicted change in unintended births.

Using this approach, we estimate that decreases in unintended births can explain 35% of the drop in fertility between 2007 and 2016. Increases in unintended births also appear to have contributed to the increases in fertility between 1997 and 2007 (explaining 9%). Changes in unintended births explain little of the overall increase in the number of births between 1980 and 1990, but that is because the PPU was falling for the first half of the decade and then rising for the latter. So, in the early 1980s, fertility rose despite falling unintended births, but in the latter half of the decade, the continued increase in fertility was largely driven by unintended births. [21] Conversely,

[21] In fact, Figure 1 shows that while the number of births was increasing steadily throughout the 1980s, the birth rate was declining for the first half of the decade before rising rapidly from 1986 to 1990. This is similar to the pattern in PPU over this time period, suggesting that changes in

disproportionate changes in unintended births are unable to explain the large fall and subsequent rise in births between 1990 and 2004, as the PPU is flat over that period. This suggests that the forces that were driving fertility changes over this middle period were affecting intended and unintended births in equal or offsetting ways.

Given the way the PPU is constructed, its fluctuations are driven by changes in the age, race, parity, and marital status of women giving birth each year. We can decompose the PPU into its component parts to better understand the relative contribution of each of these characteristics to changes in the trend. To do this, we again use the coefficients from the 2002 NSFG model, multiplied by the average characteristics of mothers in each year from the Natality Detail Files. However, we do this for one set of characteristics at a time, while setting the others at their 2002 levels. For example, to isolate the contribution of changes in the age distribution of women giving birth, we calculate the PPU for each year using the coefficients from the 2002 NSFG model and the average race, parity, and marital status from 2002, but allow the age profile to vary across years. Thus, we are able to see how the PPU would have changed if only the age profile of women giving birth had changed, but all other characteristics and their returns had remained constant at 2002 levels.

The results are in Figure 8; the solid line shows the total change in PPU from Figure 7, for reference. We draw several conclusions from this figure. First, the decline in the PPU from 2008 to 2016 is almost entirely due to changes in the age distribution of women giving birth (recall from Figure 2 that this period saw large decreases in the birth rate for women under thirty). Changes in marital status contributed only slightly, as there was a small shift away from nonmarital childbearing (Figure 3). Conversely, the increase in the PPU between 2004 and 2008 is due entirely to increases

unintended births contributed to changes in the birth rate throughout the 1980s, but population increases dominated both changes to produce an overall increase in births.

in births to unmarried women. Continuing backward, the flat PPU of the 1990s and early 2000s is the result of off-setting trends in nonmarital childbearing and declining fertility rates for young women—especially those under 25. This is also partially true for the 1980s, though early in the decade the age changes dominate while later in the period, marital status does. Throughout the period, changes in race and parity are relatively small and gradual—the changing racial composition of mothers contributed to slight decreases in the PPU over time, while the opposite is true for parity.

A potential drawback of our method of constructing the PPU is that if the "returns" to the characteristics that we use to predict unintended births change over time, our estimates could be sensitive to the choice of 2002 as the index year (the benchmark year we use in Figure 8). In Figure 9 we use three alternative years and report them in Panel A (2008), Panel B (2012), and Panel C (2014), where the predicted fraction of births that were unintended in each year is calculated in the same way as in Figure 8. While the reference point of course varies with the choice of index year, our conclusions are completely unchanged. This is a result of the fact that the coefficients in the prediction model are quite stable across years, as suggested by Table 1 and Appendix Table 2. In all panels, age is the key driver of the changes in PPU for the most recent decline, and prior to that changes in marital fertility appear to be driving the changes in PPU. This is seen most dramatically when using 2008 as the benchmark year. Between 2003 and 2008, the marriage-only line lies directly on the "all change" line. In 2008, this switches such that the age-only line lies directly on the "all change" line.

Because there have been meaningful fluctuations in the number of births to Hispanic women over this period, we have also explored the sensitivity of our results to including Hispanic ethnicity in the set of characteristics that predicts an unintended birth. We did not do this in our main analysis because Hispanic ethnicity is not reported by all states prior to 1989, but we can include it from 1989 forward. Appendix Figures 3, 4, and 5 replicate Figures 7, 8, and 9, respectively, but define race using four race/ethnicity categories rather than three, and limit the period to 1989-2016. With this change, the fraction of births that are likely unintended fluctuates more during the 1990s, but the pattern for 2000-2016 is very similar (Appendix Figure 3). It also appears in Appendix Figure 4 that changes in the racial/ethnic composition of mothers now served to decrease the number of likely unintended births during the 1990s and early 2000s, as Hispanic births were increasing and the coefficient on "Hispanic" in our prediction regression for 2002 is negative (-0.061, statistically significant at the five percent level). Nevertheless, the importance of changes in the age structure and marital status of mothers remain paramount. Furthermore, when we use other years as the index year in Appendix Figure 5, the contribution of race/ethnicity to changes in unintended births is negligible. The reason is that the coefficient on Hispanic in the prediction regressions for those years is close to zero. Ultimately, while there have been meaningful changes in the proportion of births that were Hispanic in recent decades, our conclusions about the trends in unintended births and the forces behind them are unchanged when we include this characteristic in our analysis because Hispanic ethnicity is *ceteris paribus* not a strong predictor of unintended births.

V. Discussion and Conclusion

Aggregate fertility has fluctuated considerably over the last several decades in the United States, and the last ten years have seen fertility decline to record lows. In this paper, we show how changes in unintended births have contributed to these trends. We first show that the fertility decline since 2007 has been driven by declines in births to young women and unmarried women. We use the NSFG to show that these women are also most likely to report that their births were unintended. Data from the NSFG suggest that unintended births have indeed declined since the mid- to late-2000s, but the small samples and irregular panels in the NSFG make it difficult to construct trends.

To address this, we use the NSFG to create a model of pregnancy intention based on variables that are common to the NSFG and the Natality Detail Files. We can then predict the proportion of births in the Natality Detail Files that were unintended in each year, creating a measure that is consistent over time.

Our key finding is that much of the fertility decline of the last ten years is driven by declines among women whose births were likely to be unintended, and specifically by declines in births to young women. We estimate that the predicted fraction of births that were unintended declined by 17% over this period, accounting for 35% of the overall decline in the number of births. We also show that changes in births that were likely to be unintended contributed to fluctuations in fertility in earlier periods as well—especially the increases of the 2000s and the late 1980s.

Our results raise the question: what explains the decline in unintended births over the last decade? Previous work has speculated that changes in unintended births could be due to better access to contraception, or more effective types of contraception (Finer & Zolna 2016; Snyder et al. 2018). It is unlikely that the reduction is due to changes in abortion, as the abortion rate has been falling over time, and is now at its lowest rate since Roe v. Wade (Jones & Jerman 2014, 2017). Birth rates vary dramatically across states,[22] and Kost (2015) shows that there is substantial variation across states in both the direction and magnitude of changes in the rate of unintended pregnancies. It is possible that state-level policies, including state-level differences in contraceptive access due to the Affordable Care Act, could explain some of this decline. We also observe that the decline began around the start of the Great Recession; financial difficulties in the aftermath of the downturn may have raised the cost of fertility and unintended births in particular (Stone 2018). Finally, changes in other technology (new media) have been shown to increase marriage rates, potentially improving

[22] Mathews & Hamilton (2019) document 2017 total fertility rates that range from 2,227.5 in South Dakota to 1,421.0 in the District of Columbia.

how well or how quickly partners are matched (Bellou 2015) and to decrease teen fertility (Guldi & Herbst 2017; Kearney & Levine 2015b; Trudeau 2016), which in aggregate could have also increased birth intendedness. We leave an exploration of the relative importance of these factors to future work.

Our work also has important policy implications, especially given the costs of unintended births outlined by Sonfield and Kost (2015). We can use their estimates to produce a back-of-the-envelope calculation of the public savings from the decreases in unintended births that we have identified. The authors estimate that 68% of unintended births in 2010 were publicly funded, and each of these births cost $13,962 in 2016 dollars. Our results suggest that there were 257,758 fewer unintended births in 2016 than in 2007, 175,276 of which would have been publicly funded. Thus, reducing the number of births from the 2007 level to the 2016 level saved over $2.4 billion in 2016. This estimate only reflects costs associated with the birth itself and care in the first year of life; the long term costs are likely much higher as many of these children continue to receive publicly-funded care through childhood and unintended births are associated with worse child health and development outcomes (Hummer et al. 2004). This suggests that any pronatalist policy responses to the decline in aggregate fertility may want to focus on those that would change the costs or benefits of childbearing so that *intended* births increase. This could include policies to reduce child care costs, provide job-protected parental leave, support marriage, or increase education subsidies to help alleviate the student loan burden many young adults face.

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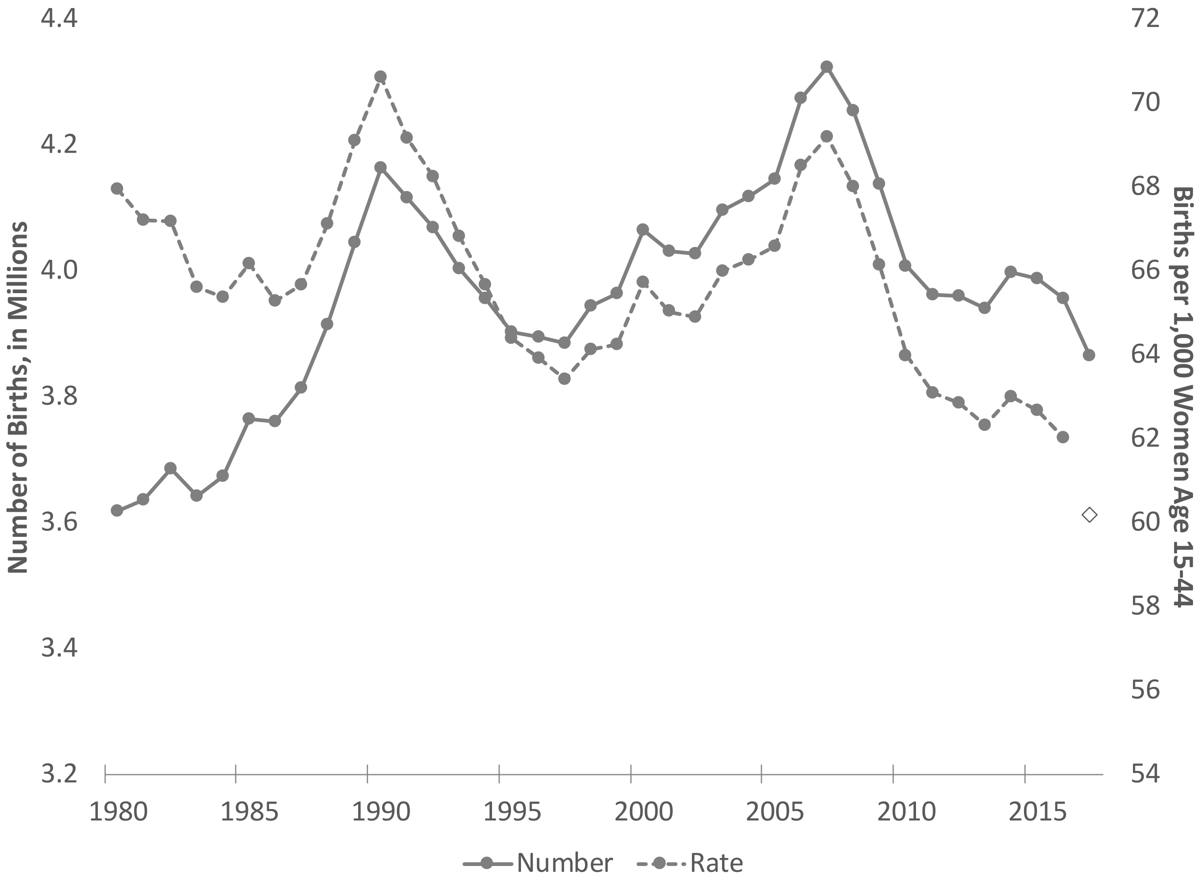
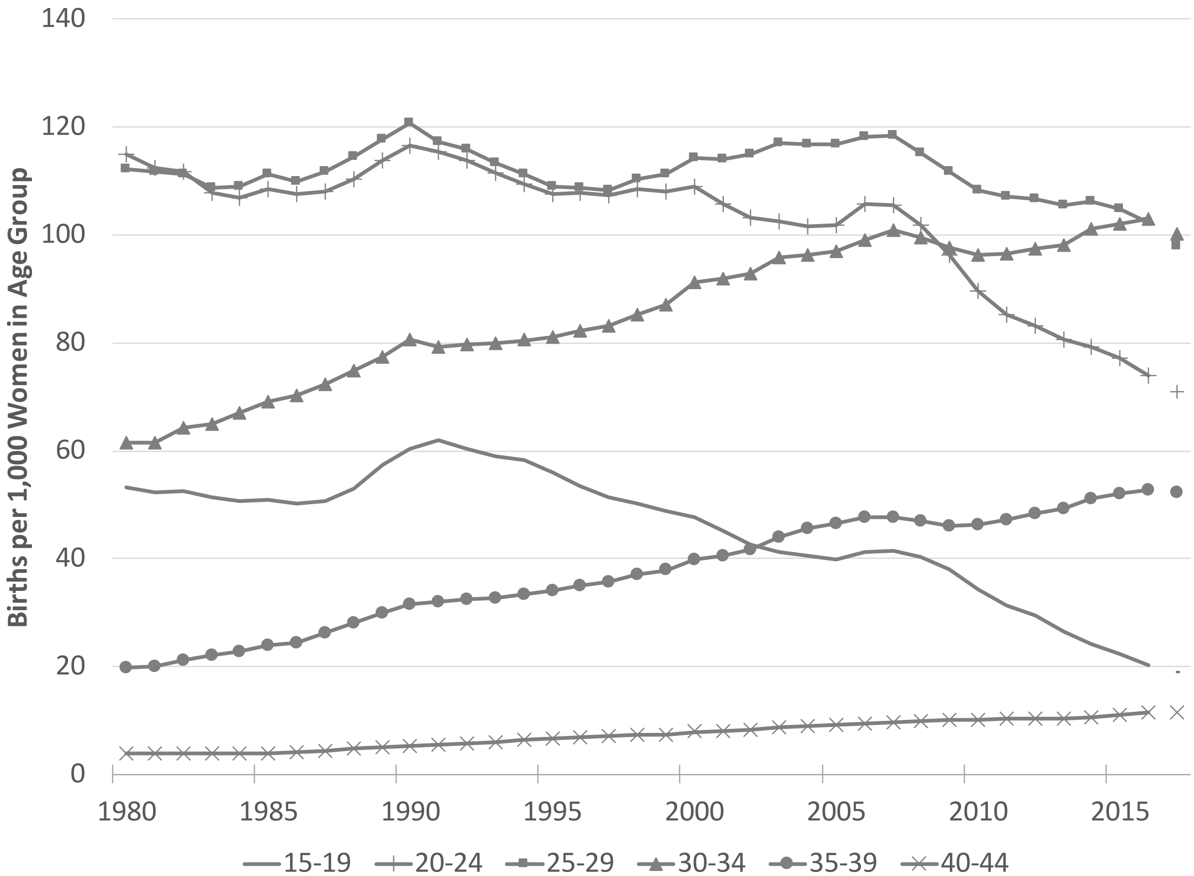
Figure 1: Number of Births and Birth Rate in the United States, 1980-2017



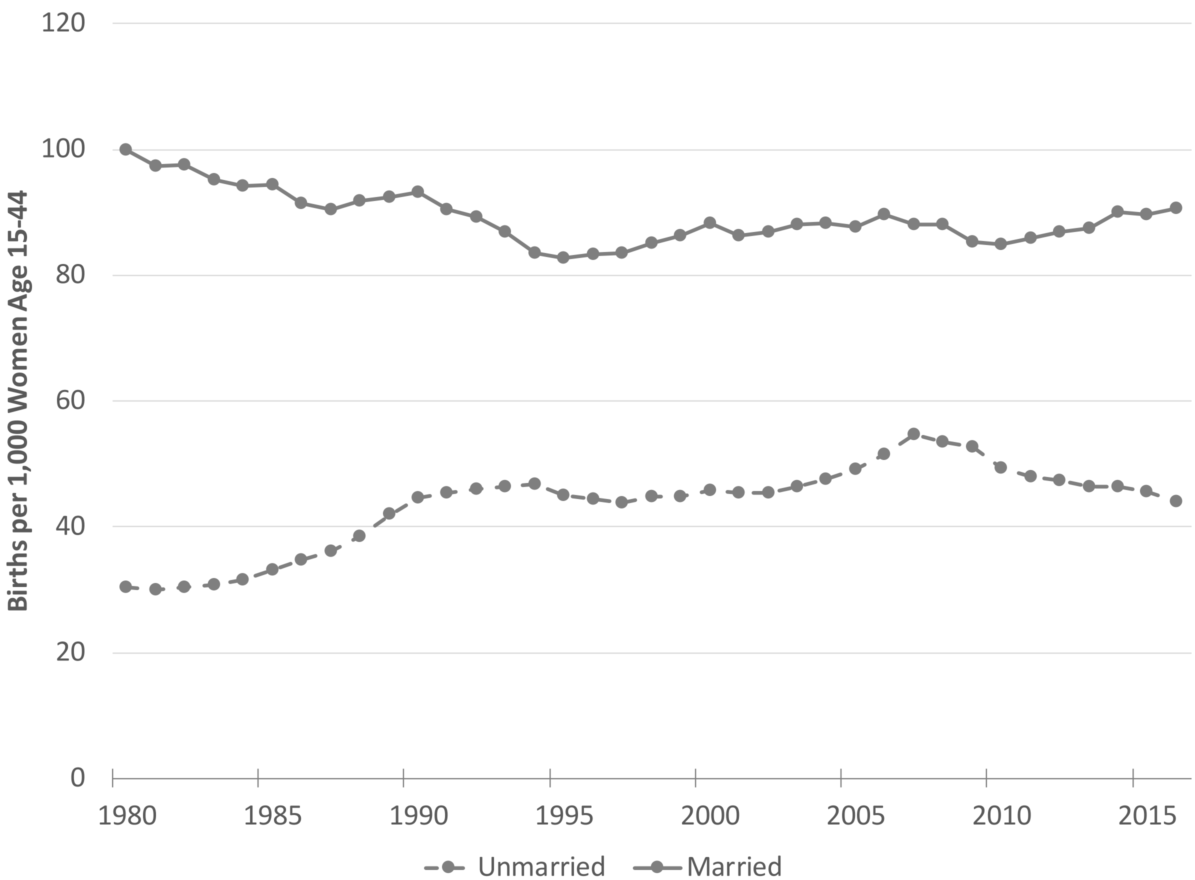
Notes: The number of births (left axis) is calculated using the Natality Detail Files, 1980-2017. Birth rates (right axis) are calculated as the number of births per 1,000 women age 15-44 (also referred to as the general fertility rate), where the population counts used in the denominator are from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER). The population counts are not yet available for 2017, so we report the provisional birth rate from Hamilton et al. (2018) (indicated with a diamond).

Figure 2: Birth Rates by Five-Year Age Categories in the United States, 1980-2016



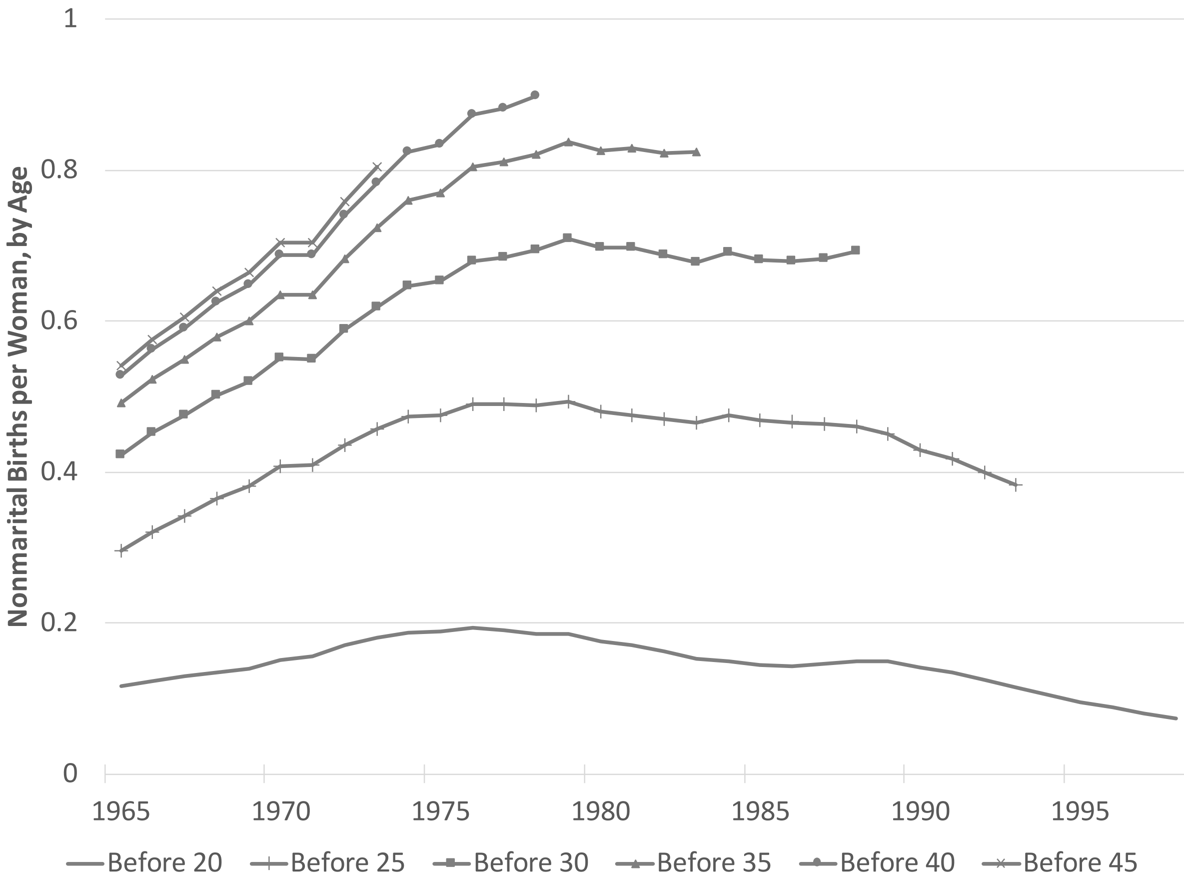
Notes: Birth rates are calculated as the number of births per 1,000 women in the age group, where the age- and sex-specific population counts used in the denominators are from SEER. The population counts are not yet available for 2017, so we report the provisional birth rates from Hamilton et al. (2018) (indicated by data points separated from the main series).

Figure 3: Birth Rates by Marital Status in the United States, 1980-2016



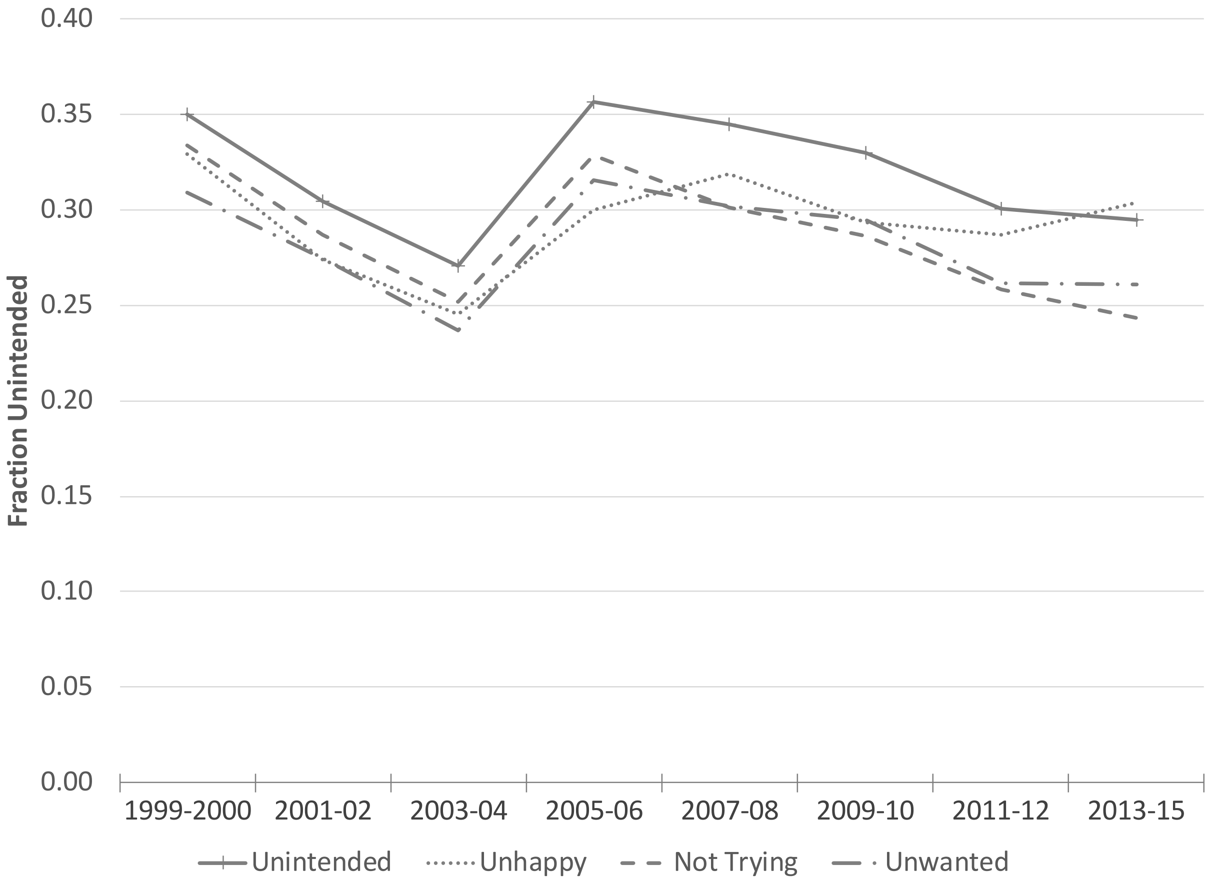
Notes: Birth rates are calculated as the number of births per 1,000 women in the marital category, where the population counts by marital status used in the denominators are calculated from the Current Population Survey Annual Social and Economic Supplement.

Figure 4: Number of Unmarried Births before Each Age, per Woman in 1965-1998 Birth Cohorts



Notes: Figure shows the number of nonmarital births per woman by the indicated age, for the 1965 to 1998 birth cohorts in the U.S. For the numerator, we estimate the mother's birth year in the Natality Detail Files using her age at birth, and then calculate the total number of nonmarital births to women of each cohort by the indicated age. The denominators are from the SEER single-year-of-age and gender population counts for the year the birth cohort turned 15.

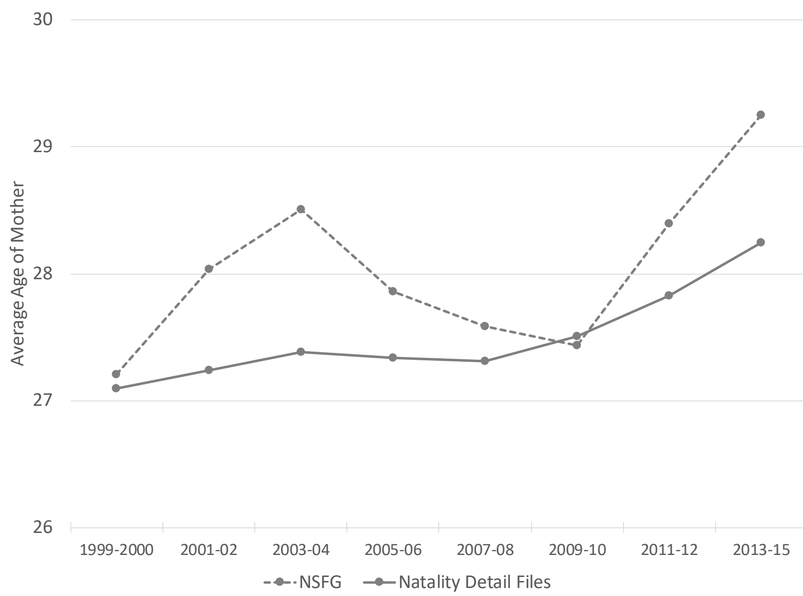
Figure 5: Fraction of Births That Are Unintended by Different Measures, 1999-2015



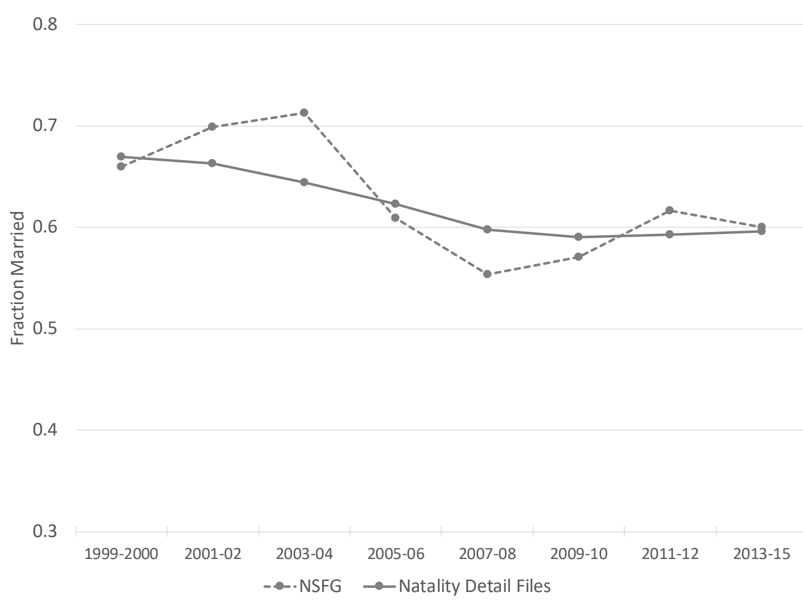
Notes: Data are from the 2002, 2006-2010, 2011-2013, and 2013-2015 cycles of the NSFG. Figure shows the fraction of births that are unintended by year of birth, using four measures: 1) an indicator for the pregnancy *either* being unwanted or occurring two years or more before the woman intended, 2) an indicator for the mother being unhappy to be pregnant, 3) an indicator for the pregnancy occurring while the woman was not trying to conceive, and 4) an indicator for whether the pregnancy was unwanted. Birth years are collapsed into two-year bins (or three in the case of 2013-15) to increase the number of observations in each data point. Results are weighted using the NSFG final weights.

Figure 6: Trends in Mother's Characteristics in NSFG and Natality Detail Files

Panel A: Average Age of Mother



Panel B: Fraction Married

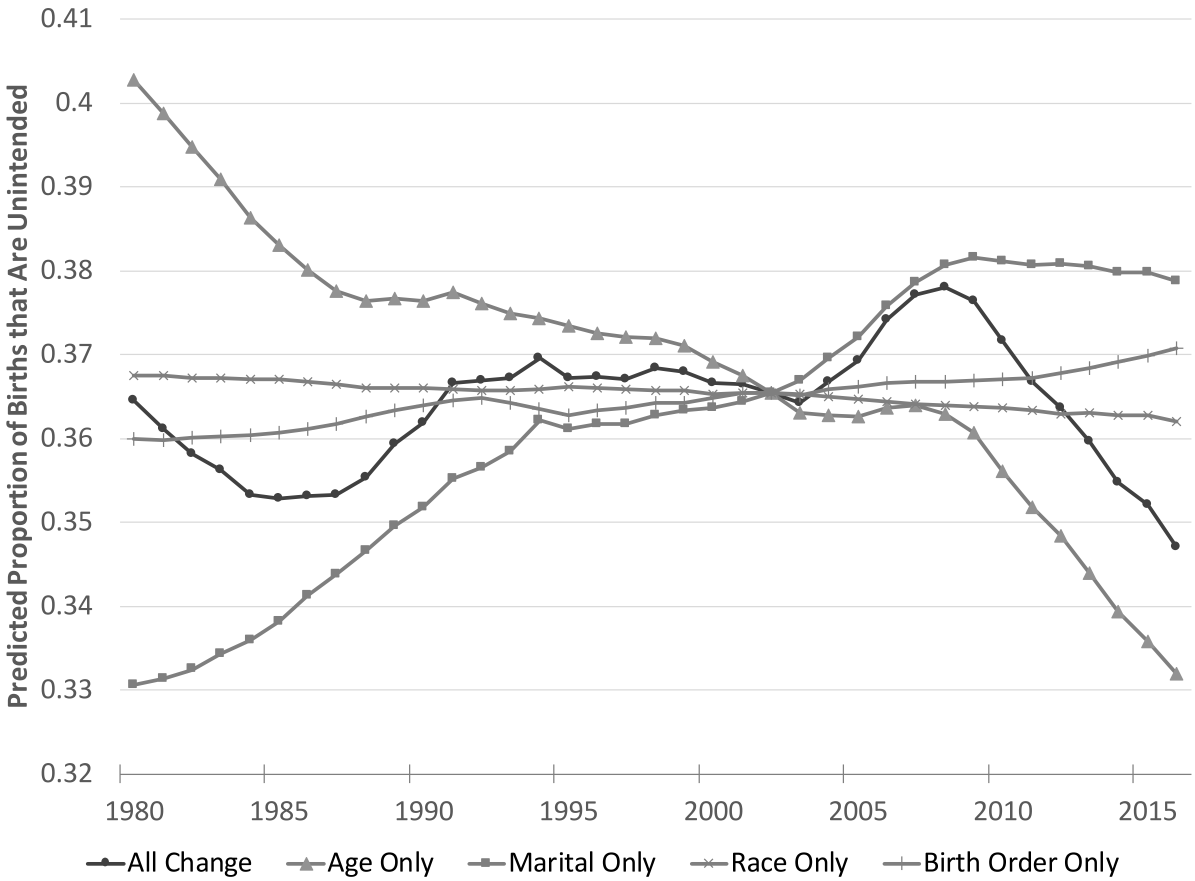


Notes: Figures show the trends in the indicated characteristic in both the NSFG data and the Natality Detail Files. Birth years are collapsed into two-year bins (or three in the case of 2013-15) to increase the number of observations in each data point. Results for the NSFG are weighted using the NSFG final weights.

Figure 7: The Predicted Proportion of Births that Are Unintended, 1980-2016, Using 2002 NSFG Coefficients

Notes: Figure shows the predicted fraction of births that were unintended in each year, based on the characteristics of women giving birth in that year in the Natality Detail Files and holding the "returns" to each characteristic constant at the level estimated using the 2002 NSFG. Here, unintended is defined as a birth in which the pregnancy was unwanted or occurred two years or more before the woman intended. See the text for a detailed description.

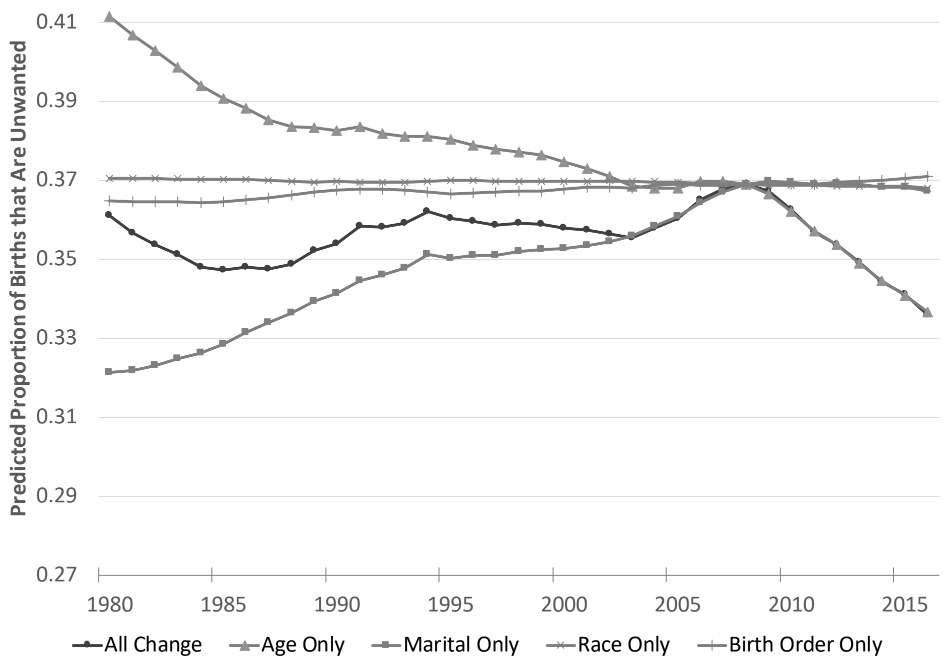
Figure 8: Decomposition of Changes in the Predicted Proportion of Births that Are Unintended, 1980-2016



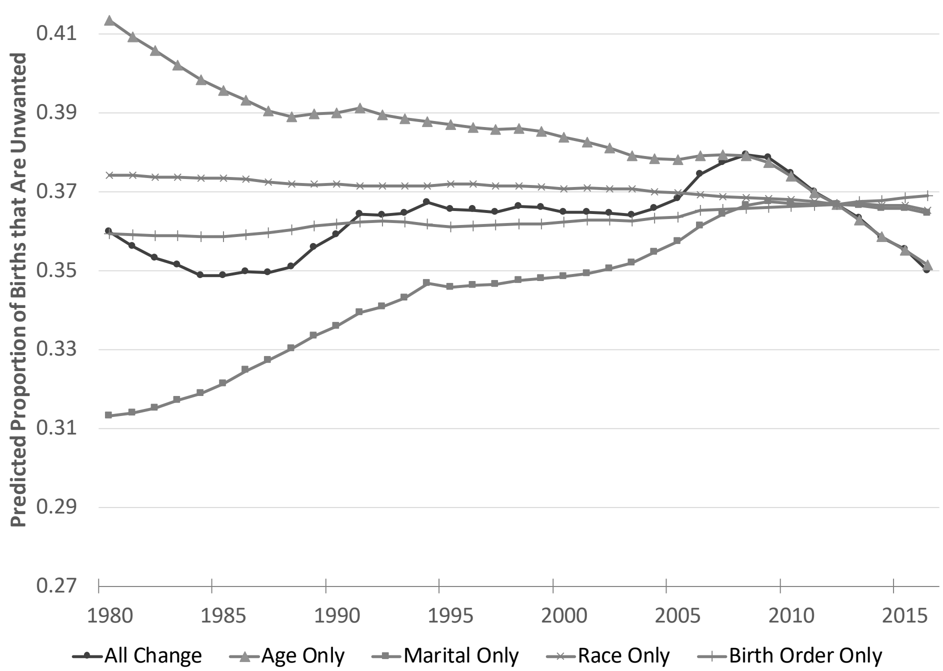
Notes: Figure shows the predicted fraction of births that were unintended in each year, based on the characteristics of women giving birth in that year in the Natality Detail Files and holding the "returns" to each characteristic constant at the level estimated using the 2002 NSFG. For the "All Change" estimate, all four characteristics (age, marital status, race, and parity) are allowed to fluctuate across years, so that the estimate is the same as in Figure 7. For each of the other estimates, only one of the characteristics is allowed to fluctuate while the others are held constant at the 2002 level. Here, unintended is defined as a birth in which the pregnancy was unwanted or occurred two years or more before the woman intended.

Figure 9: Decomposition of Changes in the Predicted Proportion of Births that Are Unintended, 1980-2016, Using Alternative Reference Years

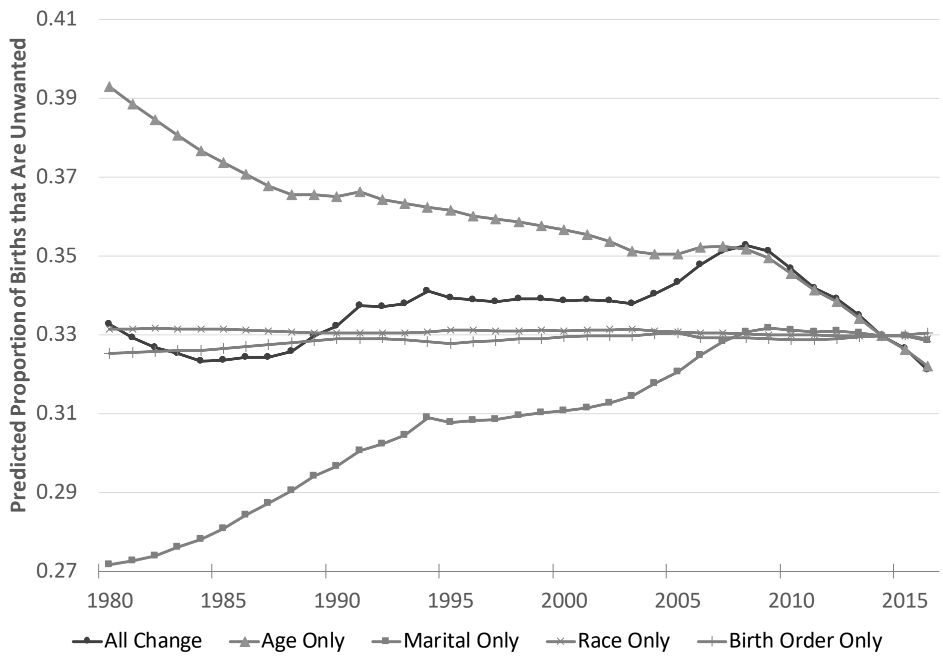
Panel A: Using 2008 as Base Year, Coefficients from 2006-2010 NSFG



Panel B: Using 2012 as Base Year, Coefficients from 2011-2013 NSFG



Panel C: Using 2014 as Base Year, Coefficients from 2013-2015 NSFG



Notes: See Figure 8. Here, the base year is changed to either 2008, 2012, or 2014, where the predicted fraction of births that were unintended in each year is calculated using the characteristics of women giving birth in that year in the Natality Detail Files and holding the "returns" to each characteristic constant at the level estimated using the indicated cycle of the NSFG.

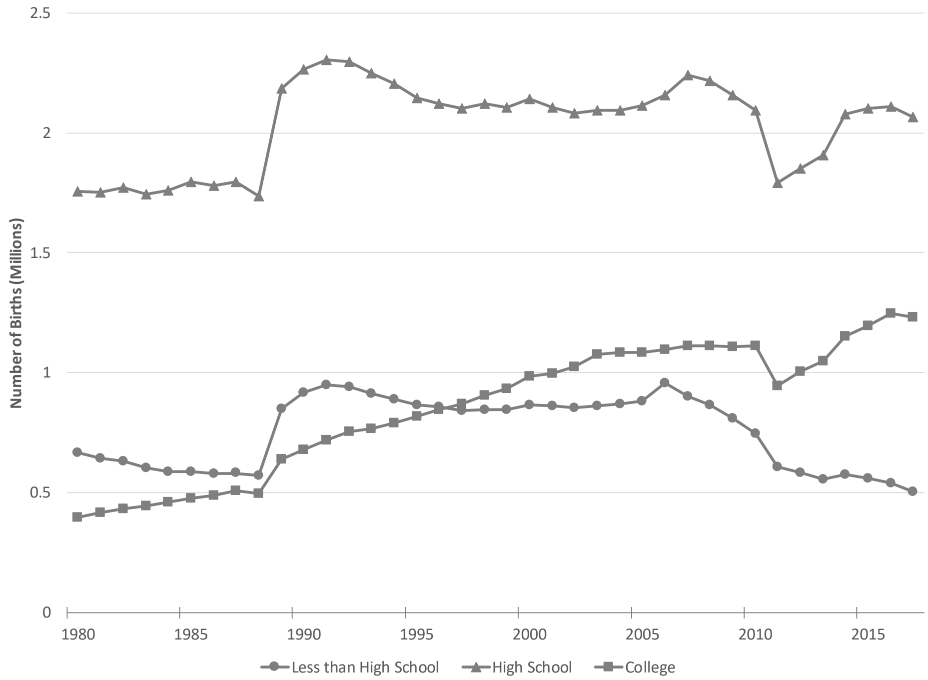
Table 1: Linear Probability Models of Likelihood that the Birth was Unintended

	NSFG Cycle			
	2002	2006-10	2011-13	2013-15
Age 15-19	0.3694***	0.3359***	0.3123***	0.2536***
	(0.0423)	(0.0399)	(0.0610)	(0.0690)
Age 20-29	0.0505**	0.0650***	0.0672**	0.0795***
	(0.0240)	(0.0230)	(0.0334)	(0.0282)
Unmarried	0.2464***	0.2175***	0.2480***	0.2711***
	(0.0318)	(0.0304)	(0.0385)	(0.0388)
Black	-0.0580*	-0.0520*	-0.0973**	-0.0790*
	(0.0331)	(0.0285)	(0.0415)	(0.0424)
Other Non-White	-0.0835*	-0.0283	-0.1418***	-0.0363
	(0.0462)	(0.0408)	(0.0504)	(0.0576)
Parity	0.0534***	0.0310***	0.0452***	0.0304**
	(0.0135)	(0.0097)	(0.0150)	(0.0122)
Mom Educ. <HS	0.0208	-0.0008	-0.0984*	-0.0022
	(0.0386)	(0.0425)	(0.0589)	(0.0492)
Mom HS,	0.0620**	0.0144	-0.0189	0.0719**
No College	(0.0289)	(0.0307)	(0.0485)	(0.0295)
<100% PVL	0.0829**	0.1338***	0.1513***	0.0945**
	(0.0337)	(0.0348)	(0.0491)	(0.0403)
100-250% PVL	0.0762**	0.0758***	0.0683*	0.0736**
	(0.0297)	(0.0283)	(0.0415)	(0.0351)
No Religion	0.0199	0.0660**	-0.0027	0.0935***
	(0.0365)	(0.0332)	(0.0358)	(0.0362)
Constant	0.0238	0.0680	0.0937	0.0030
	(0.0484)	(0.0424)	(0.0586)	(0.0519)
Fraction Unintended	0.3261	0.3426	0.3208	0.2836
Observations	2,050	3,131	1,388	1,388
R-squared	0.1607	0.1511	0.1730	0.1769

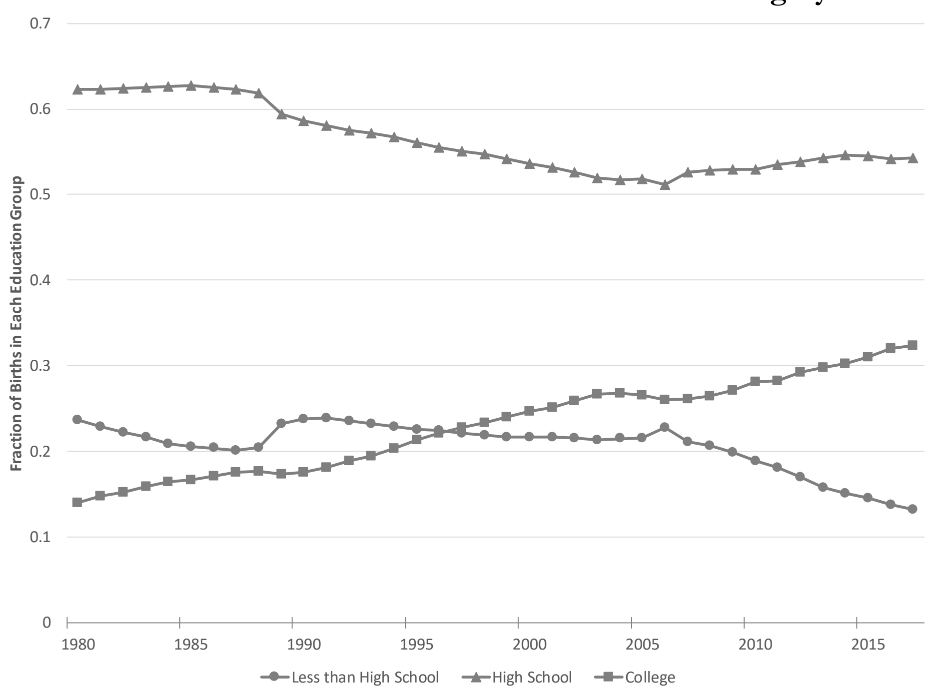
Notes: Coefficients are from OLS regressions using data from four cycles of the NSFG. For all regressions, the dependent variable is a binary variable indicating that the pregnancy was either unwanted or occurred two years or more before the woman intended. The sample is limited to pregnancies ending in a live birth. Results are weighted by the NSFG final weights. Robust standard errors are in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels.

Appendix Figure 1: Births by Education in the United States, 1980-2017

A. Number of Births by Education Category



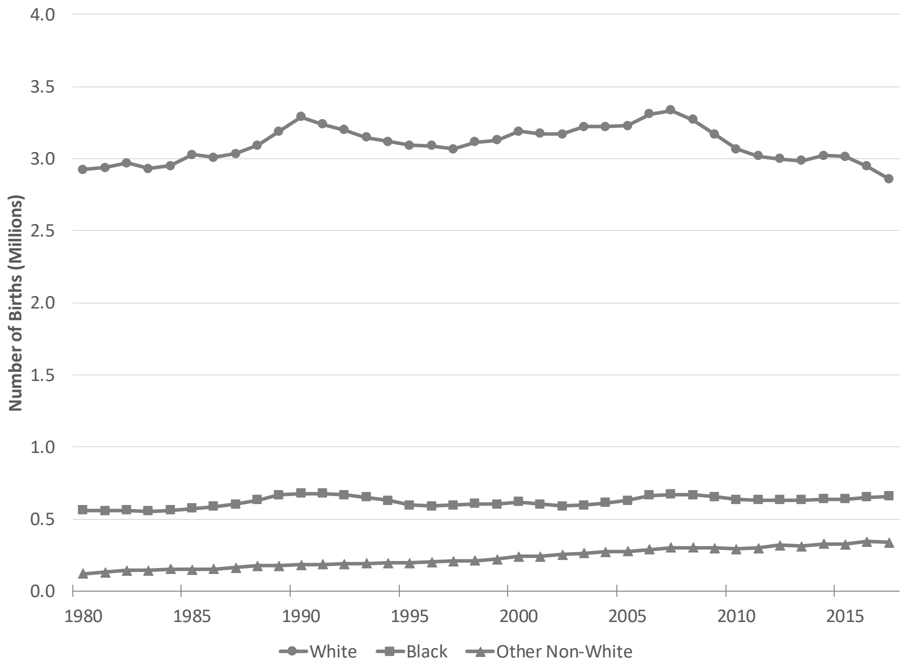
B. Fraction of Births in Each Education Category



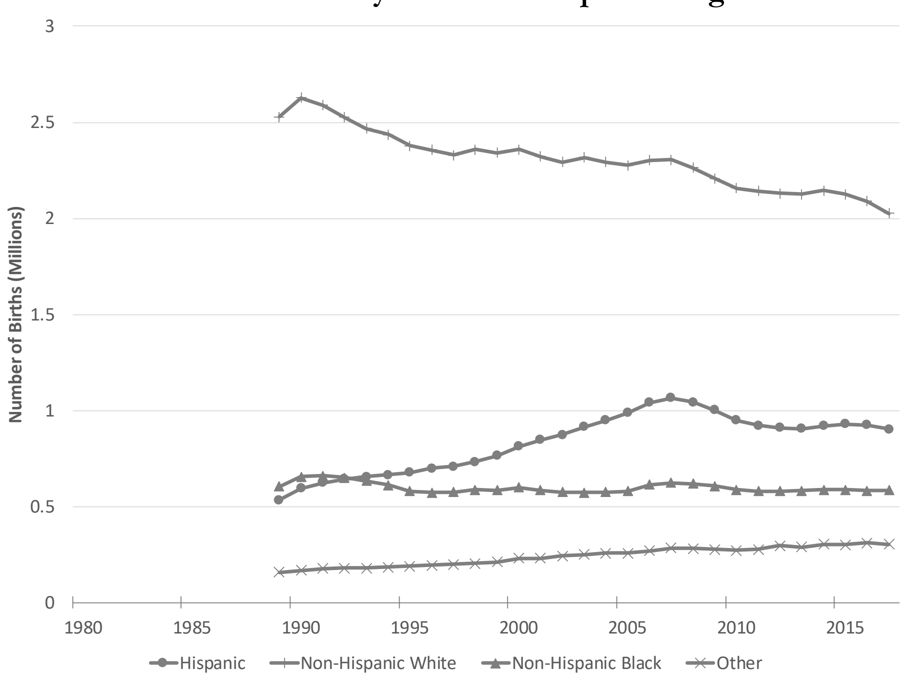
Notes: Births data are from the Natality Detail Files, 1980-2017. The number of birth certificates that report mother's education changes over the years. In both panels, births with missing mother's education are omitted.

Appendix Figure 2: Births by Race, Hispanic Origin, and Birth Order in the United States, 1980-2017

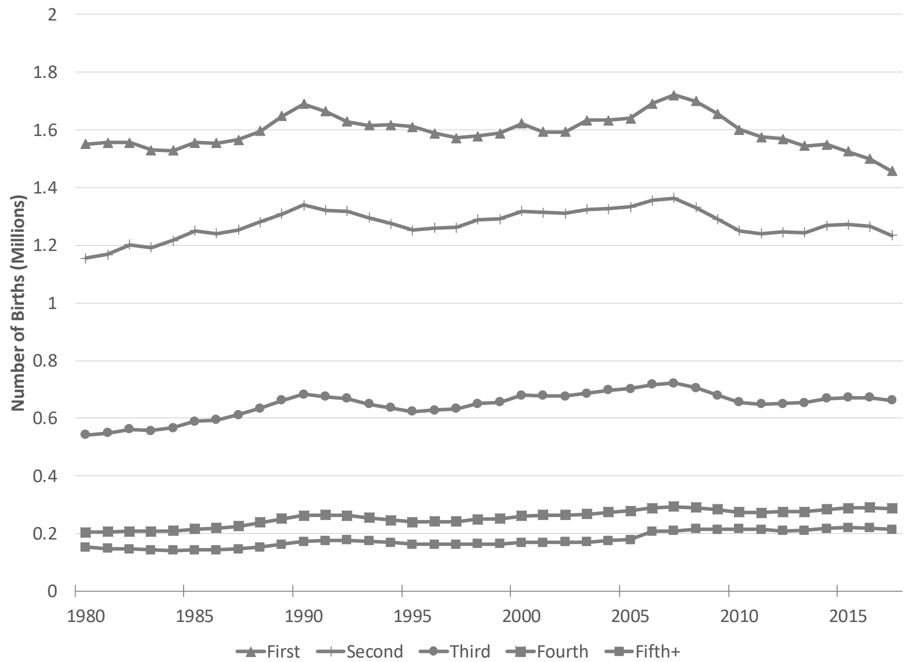
A. Number of Births by Mother's Race



B. Number of Births by Race and Hispanic Origin of the Mother



C. Number of Births by Parity

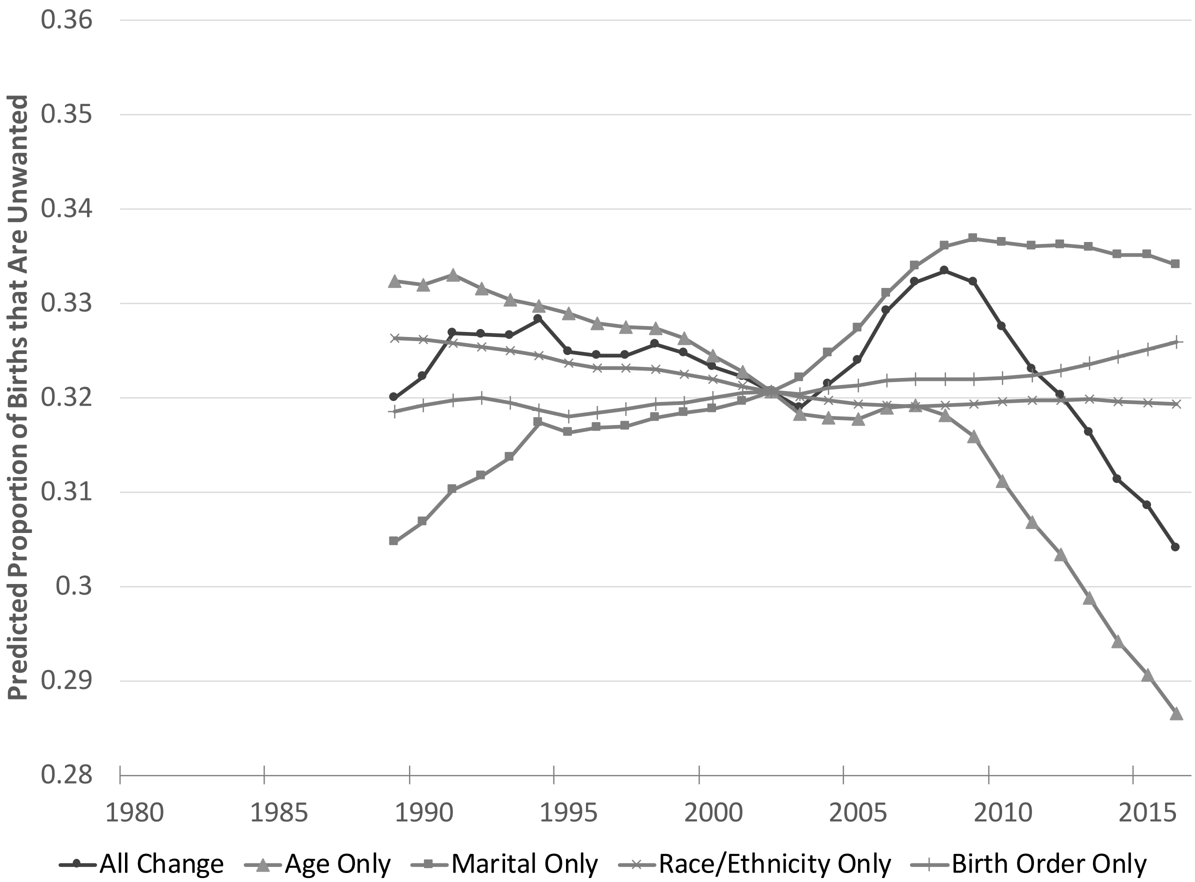


Notes: Births data are from the Natality Detail Files, 1980-2017. Hispanic origin is not reported for all states before 1989.

Appendix Figure 3: Replication of Figure 7 but Defining Race Using Four Race/Ethnicity Categories, 1989-2017

Notes: See Fig. 7. Here, "Race" is defined using four categories: 1) white, non-Hispanic, 2) black, non-Hispanic, 3) Hispanic, 4) Other. The series begins in 1989 because Hispanic origin is not reported for all states before that year.

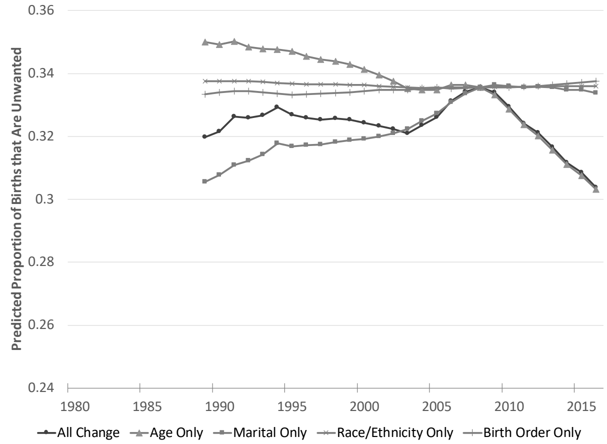
Appendix Figure 4: Replication of Figure 8 but Defining Race Using Four Race/Ethnicity Categories, 1989-2017



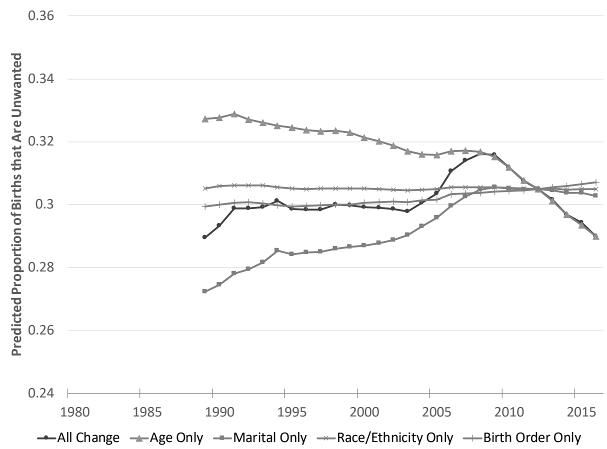
Notes: See Fig. 8. Here, "Race" is defined using four categories: 1) white, non-Hispanic, 2) black, non-Hispanic, 3) Hispanic, 4) Other. The series begins in 1989 because Hispanic origin is not reported for all states before that year.

Appendix Figure 5: Replication of Figure 9 but Defining Race Using Four Race/Ethnicity Categories, 1989-2017

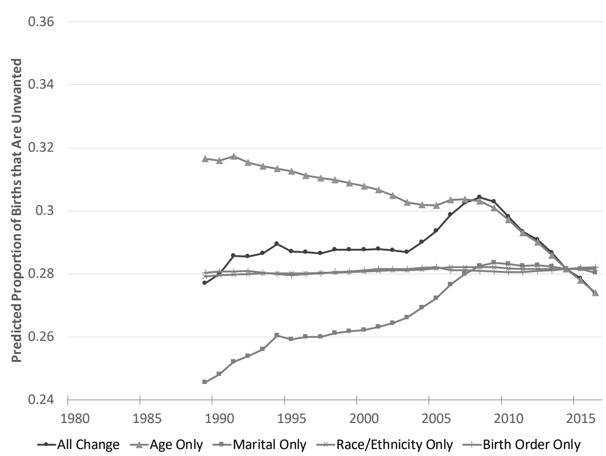
Panel A: Using 2008 as Base Year, Coefficients from 2006-2010 NSFG



Panel B: Using 2012 as Base Year, Coefficients from 2011-2013 NSFG



Panel C: Using 2014 as Base Year, Coefficients from 2013-2015 NSFG



Notes: See Fig. 9.

Appendix Table 1: Model Used to Predict Unintended Births in 2002 NSFG

	Coefficient	Standard Error	Significance
Age			
15	-0.484	0.256	*
16	-0.247	0.235	
17	-0.115	0.23	
18	-0.173	0.228	
19	-0.214	0.227	
20	-0.432	0.225	*
21	-0.350	0.224	
22	-0.447	0.225	**
23	-0.538	0.224	**
24	-0.579	0.225	**
25	-0.565	0.225	**
26	-0.659	0.225	***
27	-0.563	0.225	**
28	-0.630	0.225	***
29	-0.703	0.225	***
30	-0.618	0.225	***
31	-0.694	0.225	***
32	-0.617	0.227	***
33	-0.675	0.226	***
34	-0.525	0.227	**
35	-0.750	0.226	***
36	-0.564	0.23	**
37	-0.629	0.232	***
38	-0.671	0.235	***
39	-0.844	0.243	***
40	-0.568	0.247	**
41	-0.586	0.239	**
42	-0.756	0.667	
43	-0.720	0.506	
Married	-0.227	0.023	***
Race			
Black	-0.068	0.027	**
Other Non-White	-0.091	0.038	**
Parity			
2	0.036	0.023	***
3	0.154	0.027	***
4	0.221	0.039	***

5	0.321	0.051	***
6	0.394	0.148	
7	-0.168	0.161	
8	0.380	0.293	
9+	-0.026	0.298	
Constant	1.014	0.221	***
Observations	2,050		
R-squared	0.2447		

Notes: Table shows coefficients used to create the predicted fraction unintended in Figs. 7 and 8. Coefficients are from an OLS regression using data from the 2002 NSFG. The dependent variable is a binary indicator indicating that the pregnancy was either unwanted or occurred two years or more before the woman intended. The sample is limited to pregnancies ending in a live birth. Results are weighted by the NSFG final weights. Standard errors are robust to heteroskedasticity. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels.

Appendix Table 2: Linear Probability Models of Likelihood that the Birth was Unintended, Using Variables Common to NSFG and Natality Detail Files

	NSFG Cycle			
	2002	2006-10	2011-13	2013-15
Age 15-19	0.3877***	0.3627***	0.3130***	0.2764***
	(0.0413)	(0.0393)	(0.0656)	(0.0723)
Age 20-29	0.0757***	0.0864***	0.0874***	0.1093***
	(0.0233)	(0.0228)	(0.0317)	(0.0281)
Unmarried	0.2663***	0.2648***	0.2797***	0.3039***
	(0.0304)	(0.0269)	(0.0356)	(0.0363)
Black	-0.0642*	-0.0557**	-0.1119***	-0.0830*
	(0.0332)	(0.0283)	(0.0405)	(0.0437)
Other Non-White	-0.0883*	-0.0226	-0.1538***	-0.0516
	(0.0458)	(0.0402)	(0.0499)	(0.0596)
Parity	0.0604***	0.0443***	0.0535***	0.0382***
	(0.0128)	(0.0094)	(0.0136)	(0.0120)
	0.0852*	0.0898**	0.1001**	0.0777
Constant	(0.0440)	(0.0375)	(0.0502)	(0.0515)
	0.3877***	0.3627***	0.3130***	0.2764***
Fraction Unintended	0.3261	0.3426	0.3208	0.2836
Observations	2,050	3,131	1,388	1,388
R-squared	0.1500	0.1399	0.1658	0.1607

Notes: Coefficients are from OLS regressions using data from four cycles of the NSFG. For all regressions, the dependent variable is a binary variable indicating that the pregnancy was either unwanted or occurred two years or more before the woman intended. The sample is limited to pregnancies ending in a live birth. Results are weighted by the NSFG final weights. Robust standard errors are in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels.