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HOW MUCH CAN EXPANDING ACCESS TO LONG-ACTING REVERSIBLE CONTRACEPTIVES REDUCE TEEN BIRTH RATES?

Jason M. Lindo
Analisa Packham

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ABSTRACT

Despite a near-continuous decline over the past 20 years, the teen birth rate in the United States continues to be higher than that of other developed countries. Given that over three- quarters of teen births are unintended at conception and that over a third of unplanned births are to women using contraception, many have advocated for promoting the use of long-acting reversible contraceptives (LARCs), which are more effective at preventing pregnancy than more commonly used contraceptives. In order to speak to the degree to which increasing access to LARCs can reduce teen birth rates, this paper analyzes the first large-scale policy intervention to promote and improve access to LARCs in the United States: Colorado's Family Planning Initiative. We estimate its effects using a difference-in-differences approach, comparing the changes in teen birth rates in Colorado counties with Title X clinics (which received funding) to the changes observed in other US counties with Title X clinics. The results of this analysis indicate that the $23 million program reduced the teen birth rate by approximately 5% in the four years following its implementation, providing support for the notion that increasing access to LARCs is a mechanism through which policy can reduce teenage childbearing.

Jason M. Lindo
Department of Economics
Texas A&M University
4228 TAMU
College Station, TX 77843
and NBER
jlindo@econmail.tamu.edu

Analisa Packham
Department of Economics
Texas A&M University
4228 TAMU
College Station, TX 77843
apackham@econ.tamu.edu

1 Introduction

Despite a near-continuous decline over the past 20 years, the teen birth rate in the United States continues to be 6 to 12 times that of other developed countries (Kearney and Levine 2012). Two types of economic arguments support the view that the high rate of teenage childbearing in the United States is a problem that should be a focus of public policy. The first is based on the idea that teenagers are often not well-positioned to take care of children and, as a result, they disproportionately impose costs on family, friends, communities, and public assistance programs when they have children. Unless teenagers fully internalize such costs when they make decisions, we would expect them to have children "too often" from a social welfare perspective. The second type of argument focuses on the costs that teenagers' choices impose on themselves. While such arguments carry little weight where standard economic models of behavior can be applied, extremely high rates of unintended pregnancies among sexually active teens—more than twice the rate of older women (Finer 2010)—suggest that *homo economicus* does *not* apply to teens making choices about sexual activities. It also suggests that policies aimed at reducing unintended pregnancies have the potential to improve teenagers' welfare while reducing the negative externalities associated with teenage childbearing.

There is a long history of policies and initiatives in the United States that are geared towards reducing unintended pregnancies, particularly among teens. These approaches typically involve attempts: (i) to delay or reduce the frequency of sexual intercourse and/or (ii) to increase the use of contraceptives or promote the use of more-effective contraceptives. That said, the results of such policies have often been disappointing. Less than half of published studies that use experimental or quasi-experimental approaches to evaluate comprehensive sex education programs report significant effects on the initiation of sex, frequency of sex, or contraceptive use (Kirby 2008).[1] A randomized control trial of the Parent's Speak Up National Campaign, which promotes parent-child communication about waiting to have sex, finds no effect on adolescent's beliefs that "waiting to have sex is the best way to prevent health risks like pregnancy or HIV/STDs" (Palen et al., 2011). Moreover, the wave of state policies expanding confidential access to birth control pills during the 1960s and 1970s had little effect on teen pregnancies

[1] Kirby's (2008) review considers 48 studies of comprehensive programs. It also considers nine abstinence programs, four of which have experimental designs. While some of the non-experimental studies reviewed found significant effects on the initiation of sex and frequency of sex, the experimental studies did not. Moreover, *none* of the studies found significant effects on contraceptive use. More recently, Carr and Packham (2014) show that state-level abstinence-based sex education mandates have no effect on birth rates or abortion rates.

(Guldi 2008; Bailey 2009; Meyers 2012). That said, family planning programs appear to offer significant promise where these other policies do not. Bailey (2012) shows that the establishment of federal family planning programs in the 1960s and 1970s reduced teen birth rates 2.3% 6–10 years down the road. Kearney and Levine (2009) provide more recent evidence on the effects of family planning services in their study of state Medicaid policy changes that expanded access to higher-income women during the 1990s and 2000s—they find that these policy changes reduced teen childbearing by over 4% and argue that this effect was accomplished by increased use of contraceptives.[2]

The research described above indicates that family planning services do play a critical role in averting unintended pregnancies and births among teenagers. Yet, as over three-quarters of teen births are unintended at conception (Mosher et al., 2012), it would seem that there may be some scope for such services to play a larger role. And as a significant share of unplanned births are to women who used contraception during the month prior to conception—40% in 2001 (Finer and Henshaw, 2006)—many have argued that leveraging recent technological advances could be key. In particular, long-acting reversible contraceptives (LARCs), which include both implants and intrauterine devices (IUDs), are extremely effective at preventing pregnancy. Whereas incorrect and/or inconsistent use leads to failure rates between 6 and 9% for birth control pills, injectables, patches, and rings (and 18% for condoms), LARC methods have failure rates of less than 1% because they do not require anything of the user for at least 3 years after the initial procedure.[3] The American College of Obstetricians and Gynecologists' (ACOG) Committee on Adolescent Health Care and the American Academy of Pediatrics have both stated that LARC methods should be "first-line recommendations" for all adolescents (in 2012 and 2014, respectively), and LARCs were the focus of the Centers for Disease Control and Prevention's April 2015 report, "Preventing Teen Pregnancy." That said, only 5 percent of American teens using contraceptives are using a LARC method.[4] This low rate of use appears to be due in large part to a lack of awareness, misperceptions about safety, and costs—70 percent of adolescent participants in the Contraceptive CHOICE Project in St. Louis aged 14-20 chose a LARC method when these barriers were removed (Mestad et al. 2011). Nonetheless, a fundamental

[2]See Bailey, Guldi, and Hershbein (2013) for an overview of reproductive health policies and various approaches to estimating their causal effects.

[3]Failure rates are calculated as the number out of every 100 women who experienced an unintended pregnancy within the first year of typical use. See http://www.cdc.gov/reproductivehealth/UnintendedPregnancy/Contraception.htm.

[4]Authors' calculation using the 2011–2013 Survey of National Survey of Family Growth.

policy question remains unanswered: how much can expanding access to LARCs reduce teen birth rates?

To answer this question, we consider the first large-scale policy intervention to promote and improve access to LARCs in the United States. In particular, we examine the Colorado Family Planning Initiative, a $23 million program funded by an anonymous donor that began in 2009 with the primary goal of helping low-income women gain access to LARCs through Title X clinics.[5] The state of Colorado has pointed to the subsequent 40% reduction in its teen birth rate ("three-quarters of which was accounted for by young women served by [agencies implementing the program]") as evidence of the program's success.[6] However, the fact that teen birth rates fell significantly all across the United States over the same time period suggests that other factors probably contributed to the decline observed in Colorado. The goal of this paper is to separate out the effects of the policy initiative from the effects of these other factors in order to better understand the way in which a major investment in LARCs can affect teen outcomes. We do so using a difference-in-differences approach, comparing the changes in teen birth rates in Colorado counties with Title X clinics to the changes observed in other US counties with Title X clinics.

The results of our analysis indicate that the success of the Colorado Family Planning Initiative may have been overstated by time-series comparisons; however it *has* led to significant reductions in teen birth rates. In particular, our estimates indicate that it reduced teen birth rates in affected counties by approximately 5% in the four years following its implementation, driven by effects of approximately 7% in its second through fourth years. Our estimates further suggest that these effects were concentrated among Colorado's counties with the highest rates of poverty.

The remainder of this paper is organized as follows. In the next section we discuss LARCs in the context of the contraceptive options that are presently available to teenagers in the United States and then provide further details on the Colorado Family Planning Initiative. We then describe our empirical approach and the results of our analysis before providing some concluding thoughts.

[5]These initial funds will run out at the end of June 2015. Colorado's legislature voted against a $5 million bill to continue the program in April 2015. While initially anonymous, it has since been revealed that the donor was Warren Buffett's Susan Thompson Buffett Foundation.

[6]They also attribute reductions in the teen abortion rate and WIC caseloads to the initiatives. The press release with these statements can be accessed at: http://www.colorado.gov/cs/Satellite/GovHickenlooper/CBON/1251655017027.

2 Background

2.1 Long-Acting Reversible Contaceptives (LARCs)

LARCs include intrauterine devices (IUDs) and sub-dermal implants. IUDs are flexible, T-shaped devices that must be inserted and removed by a doctor. The most popular IUDs include the copper IUD, Paragard, and the plastic IUD, Mirena, which can protect against pregnancy for 12 and 5 years, respectively. The primary mechanism of action of both types of IUD is preventing fertilization by inhibiting sperm motility. Sub-dermal implants, such as Implanon and Nexplanon, consist of a matchstick-sized rod that contains etonogestrel. The rod is inserted into the inside of the non-dominant upper arm and can remain in place for up to 3 years.

As shown in Table 1, which provides information on the various contraceptive options that are currently available, implants and IUDs are as effective at preventing pregnancy as sterilization. During the first year of typical use, fewer than 1 in 1,000 women using an IUD or implant become pregnant. This is true with respect to "perfect use" and "typical use" of these methods because they require nothing of the user after an initial doctor's visit for insertion and thus eliminate the potential for user-compliance error. In contrast, oral contraceptives and condoms are not foolproof and have typical-use effectiveness rates of only 91% and 82% among all women, respectively, and 80% and 82% among teenagers under the age of 18 (Dineman et al., 1995; Grady et al., 1986). Moreover, because LARCs are not visible, they could be an attractive option for teens with disapproving parents or partners. Furthermore, although LARCs have high upfront costs, since they can remain in place for up to 12 years, they can be cheaper than other contraceptives in the long run.

Despite the ease of use and benefits of LARCs, merely 5% of the 3.2 million teenage women using contraceptives in the United States chose to use an implant or IUD in 2013, and only 8.5% of all US women using contraceptives choose a LARC (Guttmacher, 2014; NSFG 2011-2013). This figure stands in stark contrast to other countries where, for example, 41% of women use a LARC in China and rates vary between 6% and 27% in Europe.[7] There are several potential explanations for the low rate of LARC use among US teens. First, teens may be unaware that LARCs are a viable option. Second, there may be misconceptions about safety and protecting against sexually transmitted diseases (Bharadwaj et al., 2012). Third, insertion is uncomfortable

[7]See Finer et al. (2012) for more details. Rates available for European countries are as follows: Austria, 15%; Baltics: 14%; Czech Republic, 10%; Denmark, 18%; France, 17%; Germany, 10%; Spain, 6%; Sweden, 21%; and UK, 11%.

and sometimes painful, and LARCs may cause side effects such as menstrual pain and bleeding, spotting, headaches, nausea, and mood changes, although these side effects are similar to those associated with other hormonal birth control methods.[8] Fourth, teens may be discouraged by the high upfront costs of the devices. Out-of-pocket costs for implants and IUDs are upwards of $400, and even insured teens may pay up to a $160 copayment to receive a LARC (Trussell et al., 2009; Planned Parenthood). In support of the importance of this consideration, Mestad et al. (2011) find that 70% of adolescents who are aware of the benefits of LARCs choose a LARC when it is offered at no cost. Finally, there are supply-side barriers to LARC access. Doctors and nurses must be trained on proper LARC insertion/removal and side effects counseling. Moreover, health clinics that provide free and low-cost contraceptives generally cannot afford to offer LARCs to all clients—many Title X clinics do not offer LARCs at all, and those that do must offer them to clients selectively.[9] As discussed in greater detail below, The Colorado Family Planning Initiative sought to improve access to LARCs by addressing several of these issues.

2.2 The Colorado Family Planning Initiative

In this section we highlight the most important features of the Colorado Family Planning Initiative as they relate to our analysis. Our description of the policy's implementation draws heavily from conversations with the Colorado Department of Public Health and Environment and the detailed discussion provided in Ricketts et al. (2014).

In January 2009 the Colorado Department of Public Health and Environment (DPHE) implemented the Colorado Family Planning Initiative (CFPI) with the intent to reduce unintended pregnancy via increased access to long-acting reversible contraception. The Colorado DPHE received $23 million in provisional funding from an anonymous donor to provide free LARC methods to low-income women in Title X clinics. All of Colorado's 28 agencies accepted funding, which was to be distributed to Title X clinics in 37 counties through June 2015. Money was allocated proportionally to agencies based on their number of clients and the predicted number of LARC insertions in the following year.

[8] More serious and rare side effects can occur for patients with IUDs and include pelvic inflammatory disease, uterus perforation, and ectopic pregnancies. Risk of pelvic inflammatory disease occurs in 1 in 100 cases, and is no greater with an IUD than the risk to the general population. Uterus perforation occurs in less than 1 in 1000 cases. Ectopic pregnancy is the most serious and rare possible side effect of an IUD. In rare events in which a women becomes pregnant while using an IUD, the risk of having an ectopic pregnancy ranges from 6–50% (Grimes, 2007).

[9] Just 39% of all Title X clinics in 2010 offered implants, and only 63% provided IUDs (FPAR, 2013).

The CFPI provided support for 3 main objectives: supplying free IUDs and contraceptive implants to low-income women, equipping staff and providers with more knowledge about LARC insertion, promotion, and counseling, and providing technical assistance for billing, coding, and clinic management. Additionally, CFPI offered general assistance to Title X agencies to increase the utilization of LARCs and supported the provision of NuvaRing, tubal ligations and vasectomies. We note, however, that the use of NuvaRing remained fairly constant at roughly 5% among teen clients after the CFPI was implemented and that tubal ligations and vasectomies are extremely rare among teens.[10]

Title X clinics receive federal and state funds to provide free or low-cost counseling, sexually transmitted disease screening, and contraceptives. At Colorado Title X clinics anyone at or below 100% of the poverty level pays nothing, and no client is denied services because of an inability to pay. Patients who earn between 101%-250% of the poverty level pay a discounted rate and clients earning above 250% of the poverty level pay the full cost of the visit. Agencies must accept verbal communication of income and no verification is necessary.

In Colorado, 90% of Title X clients fall into the "very low income" bracket, meaning that nearly all clients pay nothing for contraceptives and doctor visits. The high upfront costs of LARC devices paired with the sliding fee schedule meant that historically many clinics could not afford to provide implants and IUDs. At clinics that supplied LARCs prior to the CFPI, devices were inserted only for women that were subjectively considered the most "at risk" for an unintended pregnancy. The CFPI funding was critical for all Title X clinics to be able to stock and provide these highly effective contraceptives to clients. In 2009, 20 out of 28 agencies offered IUDs for the first time and 16 agencies offered the implant for the first time. At the end of the first year of the initiative, all agencies offered IUDs and all but one agency offered implants.

Figure 1 shows how the primary method of contraception used by female teenagers (ages 15-19) visiting Colorado Title X clinics has evolved over time. In 2008, the year before the initiative began, LARCs had a lower usage rate than condoms, injections, rings, and birth control pills at less than 3%. By 2014, LARC take-up among teens had risen to nearly 25%, surpassing all methods except oral contraceptives. In broad terms, Colorado teens substituted away from methods with relatively low typical-use success rates towards highly effective devices

[10]Nuvaring is a vaginal ring inserted once a month and left in place for three weeks. Like birth control pills, it prevents pregnancy by releasing estrogen and progestin.

over time. We also note that these statistics may understate the degree to which LARC use has increased in Colorado because the statistics for each year are based on clinic *visitors*, and the long-acting quality of LARCs may reduce the likelihood of a return visit to a clinic. Regardless, as depicted in Figure 2, the increase among teens visiting Colorado clinics stands apart from what has happened across the United States as a whole. In particular, despite starting at the same low rate in 2008, LARC usage among teens visiting Title X clinics across the US only grew to approximately 6% by 2013 versus 21% for Colorado.

Further demonstrating what an outlier Colorado has become in promoting the use of LARCs among teens visiting Title X clinics, Figure 3 presents a state-by-state comparison of teen LARC usage by Title X clients in 2013. It shows that only 6 states have LARC usage above 11%, and Colorado has the highest usage rate at over 21%. As a whole, these statistics support the notion that Colorado clinics were successful at introducing teens to highly effective contraceptive methods after the implementation of the CFPI.

Figure 4 shows the number of teen females visiting a Title X clinic in Colorado over time along with the number of teen clients whose primary method of contraception was a LARC. These are of interest because a spike in the number of clients after the program was implemented could suggest that CFPI was effective in attracting new clients to Title X clinics. Alternatively, a decline in clients could imply that the number of clients receiving LARCs has not risen by as much as we would expect based on the earlier figures. That said, Figure 4 does not show a spike in the number of clients but, rather, shows an increase and a subsequent decrease in the number of clients, which is consistent with the fact that the teen population increased and then decreased over the same period (Panel A). Moreover, the figure also shows that the number of teens visiting Title X clinics in Colorado using LARCs increased over this period in a significant manner (Panel B).

3 Empirical Approach

In this section we provide details on the data used in our analysis and on our strategy for estimating the causal effects of the Colorado Family Planning Initiative.

3.1 Data

Our analysis focuses on teens between the ages of 15 and 19 living in counties with Title X clinics. The locations of Title X clinics in Colorado—all of which participated in the Colorado Family Planning Initiative—were obtained from the Colorado Department of Public Health and Environment's Directory of Family Planning Services. Counties with Title X clinics outside of Colorado were identified by geocoding the addresses of such clinics listed in the US Department of Health and Human Service's 340B Database. According to the National Family Planning and Reproductive Health Association, over 90% of Title X clinics participate in the 340B Drug Pricing Program and thus would be reflected in the database (NFPRHA 2013).[11] The resulting set of counties that are used in our analysis are depicted Figure 5. In total, 72% of counties are included in the analysis, which account for 93% of the population of female teenagers in the United States.

In order to estimate the effect of the initiative on teen births, we use restricted-use natality files (provided by the National Center for Health Statistics) from 2002–2013.[12] These data consist of a record of every birth taking place in the United States over this time period and include information on the mother's age and the county of the birth, which are critical to our analysis, in addition to other details on the mother, the father, and the child. We assign births to the year of conception based on the mother's last menstrual period where available and otherwise assume a gestation period of nine months. As such, we have incomplete data on births conceived in 2013 and thus restrict our analysis from 2002–2012 after making use of the 2013 natality file to construct our measure of teen births conceived in 2012. We use these data in conjunction with population counts from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER) in order to consider teen birth rates in our analysis.[13]

Because our empirical strategy (described in the next section) controls for county-specific and year-specific characteristics with fixed effects, we only consider time-varying county characteristics as control variables. These include demographics (fraction of 15–19 females of each age, black, and Hispanic) constructed from the population data described above and the unem-

[11] For Colorado, one of 37 counties would have been excluded from the analysis if we solely used data from the 340B Database.

[12] The choice of the initial year used for the analysis is motivated by the fact that Broomfield County, Colorado, split off from Adams, Boulder, Jefferson, and Weld counties in November of 2001.

[13] SEER population estimates are based on an algorithm that incorporates information from the Census, Vital statistics, IRS migration files, and the Social Security database. Note that we omit from the analysis one county that has a Title X clinic and zero teen females in a year.

ployment rate from the Bureau of Labor Statistics.

Summary statistics for the variables used in the analysis are shown in Table 2. Means for the sample of Colorado counties and comparison counties are separately reported pre-2009 (before the enactment of the Colorado Family Planning Initiative) and post-2009. Teen birth rates prior to 2009 across treatment and comparison counties average 40 and 48, respectively, and teen birth rates for both groups decline after 2009. In the analysis below we intend to shed light on the degree to which the reduction observed in the Colorado counties was caused by the Colorado Family Planning Initiative.

3.2 Identification Strategy

As we alluded to above, we estimate the effects of the Colorado Family Planning Initiative with a difference-in-differences approach that uses counties with Title X clinics outside of Colorado to form the comparison group for Colorado counties with clinics receiving funding (i.e., those with Title X clinics). The identifying assumption underlying this approach is that the proportional changes in birth rates in the comparison counties provide a good counterfactual for the proportional changes that would have been observed in the Colorado counties in the absence of the initiative. We discuss the validity of this identifying assumption in greater detail below.[14]

Given the discrete nature of the births and because we sometimes have county-year cells with zero teen births, our preferred approach uses a Poisson model.[15] In particular, our main results are based on estimating Poisson models of the following form:

$$E[TBR_{ct}|CFPI_{c,t-k}, \alpha_c, \alpha_t, X_{ct}] = exp(\sum_{k=1}^{4} \theta_k CFPI_{c,t-k} + \alpha_c + \alpha_t + \beta X_{ct}) \quad (1)$$

where TBR_{ct} is the teen birth rate for county c in year t, $CFPI_{c,t-k}$ is an indicator variable that takes a value of one for Colorado counties k years after the CFPI began and zero otherwise, α_c are county fixed effects to control for any systematic differences across counties, α_t are year

[14]We have also considered using a broader comparison group comprised of all US counties and a narrower comparison group comprised of counties in states bordering Colorado. Neither appear to track the Colorado counties as closely as our chosen comparison group prior to the intervention, suggesting that they are would provide a less reliable counterfactual. We have also considered using Colorado counties without a Title X clinic as the comparison group but, because these counties tend to be sparsely populated, such an approach yields estimates that are too imprecise to be meaningful.

[15]Like linear models, the Poisson model is not subject to the incidental parameters problem associated with fixed effects because they can be eliminated from the model. We relax the assumption of equality between the conditional mean and variance by calculating sandwiched standard errors.

fixed effects to control for shocks to teen birth rates that are common to all counties in a year, and X_{ct} can include time-varying county control variables (including state-specific trends). As Poisson models are more typically thought of as considering counts and not rates, we note that this model can alternatively be expressed as one that estimates the natural log of the expected count of births while controlling for the population of teen females and constraining its coefficient to be equal to one. We also estimate weighted least squares analogues to Equation 1 (adding one to the count of births for all county-year cells) and all analyses allow errors to be correlated within counties over time when constructing standard-error estimates.

There are two reasons why it is important for the model to allow the estimated effects to vary across years with a set of indicator variables as opposed to attempting to estimate the average effect across years with a single indicator variable. First, the nature of contraceptive choice, sexual activity, and childbearing all would suggest that any effect would be appear some time after the program's implementation even when we assign births to their year of conception. In particular, the share of sexually active teens using LARCs is expected to increase over time as they visit clinics and, more generally, become more aware of this option, which is evident in figures 1 and 2. Moreover, teen sexual encounters are often irregular and sexual encounters only lead to pregnancy with some probability.

The second reason this approach is important is because we estimate models that include state-specific linear trends to address concerns that differences in the pre-existing trends between counties with Title X clinics in Colorado and counties with Title X clinics in other states might bias estimates derived from Equation 1.[16] As explained in Wolfers (2006), estimates of such trends will be biased—as will the estimates of other parameters—when a model does not fully account for time-varying treatment effects. In plain terms, a time-varying treatment effect implies an effect on trends, which in turn implies that including trends that are identified in part by the post-treatment data would be "overcontrolling" (i.e., controlling for an endogenous variable), which can lead to significant bias. This source of bias is not an issue if the post-treatment observations do not contribute to the estimates of the trends, which can be accomplished by allowing the estimated effects to vary over time in a fully non-parametric fashion. In our case, this entails allowing the effect to vary across years. Nonetheless, we note that the estimated effects for each year are sometimes imprecise and, as a result, we may prefer to focus on their

[16]We additionally estimate models including county-specific linear trends when considering weighted least squares.

average across years and the statistical significance of their average across years.

4 Results

4.1 Main Results

Before presenting model-based estimates, we first present a graphical analysis that corresponds to our difference-in-differences identification strategy. In particular, Panel A of Figure 6 plots the simple average of teen birth rates across Colorado counties with Title X clinics, which received funding from the CFPI, against the average teen birth rate across other US counties with Title X clinics. Panel B is similar but weights counties by their teen female population. Of particular note to the validity of our empirical approach, average birth rate for the Colorado counties appears to track that of other US counties fairly well prior to the CFPI, supporting the notion that the changes for the latter can provide a good counterfactual for the former. That said, the teen birth rate trend for the Colorado counties is somewhat more negative than that of the non-Colorado counties—particularly when considering the weighted average—which suggests that it may be important to control for state trends in some specifications. Figure 6 also suggests that the teen birth rate across Colorado counties diverges from that of other US counties following the CFPI, providing some initial evidence that the initiative had its intended effect of reducing teen birth rates. In the discussion of results below, we consider the statistical significance of this apparent effect and its magnitude under alternative modeling approaches.

Table 3 presents estimates of the effect of the initiative on teen birth rates based on the Poisson model described by Equation 1. The estimated effects from the baseline model (only controlling for county and year fixed effects) are shown in Column 1 while Column 2 shows the estimated effects from a model that additionally controls for economic and demographic factors. Specifically, these controls include the county unemployment rate and the fraction of teens of each age and race/ethnicity. These estimates indicate that the initiative reduced teen birth rates by 4–6% in its first year and that the effect grew to 16–17% by its third and fourth years.

The estimates shown in columns 3 and 4 address the possibility that the estimates from the baseline model may be biased if Colorado counties with Title X clinics and other US counties with Title X clinics differ in their pre-existing birth rate trends, which could be the case if, for example, there are social factors affecting birth rates differentially across states and counties

over time. In particular, the estimates in columns 3 and 4 are based on a model that additionally includes state-specific linear trends, with and without economic and demographic control variables, respectively. The estimates in these two columns are smaller than those in columns 1 and 2, reflecting that the birth rate trend for the Colorado counties was somewhat more negative than the trend for non-Colorado counties. Nonetheless, the estimates continue to indicate that the initiative reduced teen birth rates after its first year—by 4% in its second year, 9% in its third year, and 7% in its fourth year.

That said, because the estimated effects and their levels of statistical significance vary across years, we suggest that they be interpreted with caution. Towards this end, Table 3 also reports averages of the estimated effects across years and p-values associated with tests that these averages are zero. For the richest specification (Column 4), the estimates imply that the initiative reduced teen birth rates by 5% across four years (p-value = 0.039), or 7% across its second through fourth years (p-value=0.019).

As the CFPI was intended to help *low-income* women gain access to LARCs, one would reasonably expect the effects to be greatest in counties with a relatively large share of low-income individuals. We investigate this by separately considering the effects for counties with poverty rates above the median of Colorado counties with Title X clinics and those with poverty rates below this median.[17] While this approach balances the number of Colorado counties contributing to each estimate, we note that Colorado is a relatively low-poverty state and, thus, that the median being used here (12.2%) is higher than the median across non-Colorado counties with Title X clinics (15.6%).

The results of this analysis are shown in Table 4, which presents estimates based on models with state-specific linear trends—demonstrated to be important above—both with and without economic and demographic controls. These estimates indicate that the initiative reduced teen birth rates by 6–8% over four years in Colorado's counties with poverty rates above its median and, as before, that these effects are concentrated in the second through fourth years of the program. The estimated effects for Colorado's counties with lower poverty rates point in the same direction, suggesting that the initiative reduced birth rates, but they are roughly half as large as the estimates for higher poverty counties and are not statistically significant at conventional levels.

[17] We use each county's poverty rate averaged across 2002–2012 so that this approach maintains a balanced panel.

4.2 Results from Alternative Models

In this section, we discuss the results from several alternative models, all of which continue to control for county fixed effects, year fixed effects, economic and demographic controls, and state-specific linear trends. We first focus on investigating the sensitivity of our main results to the inclusion of leads and then consider least squares estimates as an alternative to Poisson-based estimates.

In Table 5 we show the results from Poisson models that additionally include indicator variables for Colorado counties prior to the beginning of the initiative. We do so in order to verify that the teen birth rate in the Colorado counties did not deviate from expected levels relative to the teen birth rate in other US counties prior to the initiative, which would otherwise cast doubt on the notion that they provide a good comparison group for our purposes. Indeed, the coefficient estimates on the lead terms are routinely close to zero and are never statistically significant whether focusing on all counties (Panel A), counties with poverty rates above the Colorado median (Panel B), or counties with poverty rates below the Colorado median (Panel C). Moreover, these results show that the estimated effects of the initiative are robust to the inclusion of these lead terms (though less precise), providing additional support for the validity of the research design.

We now turn to estimates of the effect of the initiative using weighted least squares (WLS) where each cell is weighted by the teen female population it represents. We note that this approach requires an ad hoc solution to address the fact that the natural log of the teen birth rate is undefined for county-year cells with zero teen births and that we address this issue by adding one to the birth count in all cells.[18] We also estimate specifications of the WLS model that include county-specific linear trends in order to control for unobserved heterogeneity in a more flexible manner.

These WLS estimates are shown in Table 6. Specifically, the results in the odd columns are based on the model that includes state-specific linear time trends and the results in the even columns are based on the model that includes county-specific linear time trends. Columns 1 and 2 show results based on all counties while columns 3 and 4 show results based on counties with poverty rates below the Colorado median and columns 5 and 6 show results based on

[18] While it is usually useful to also present OLS estimates for comparison with WLS estimates, as described in detail in Solon, Haider, and Wooldridge (2015), we believe that OLS is unreliable in our context because of the weight it gives to small counties for which the outcome variable is disproportionally affected any ad hoc solution to addressing cells with zero births.

counties with poverty rates above the Colorado median. We take two main things away from these results. First, the magnitude and precision of the estimates are unaffected by the inclusion of county-specific linear trends, which supports the validity our preferred approach that uses a Poisson model and controls for state-specific linear trends but not county-specific linear trends. Second, though the estimates are sometimes smaller in magnitude, they provide evidence in support of the main results. In particular, they indicate that the initiative reduced birth rates by 6% across its second through fourth years (compared to Poisson-based estimates of 7%). And they indicate that the effects are concentrated in counties with relatively high poverty rates where the estimated effects are 9–10% across the initiative's second through fourth years (virtually identical to the Poisson-based estimates). They also echo the earlier estimates which suggested that there may have been smaller effects in counties with lower poverty rates but, as before, these estimates are not close to being statistically significant at conventional levels.

5 Conclusion

This paper provides some groundwork for understanding how improving access to LARCs can affect birth rates of one of the highest at-risk groups for unintended pregnancy—teenagers—by analyzing the first large-scale policy intervention to promote and improve access to LARCs in the United States. Our estimates indicate that Colorado's $23 million initiative, which began in 2009, significantly reduced teen birth rates. The magnitude of the estimated effects imply that the program prevented over 900 teen births that would have been conceived through 2012.[19] While this amounts to approximately $25,000 per teen birth, it is important to keep in mind that the $23 million investment was to fund the program from the beginning of 2009 through June 2015 and that our analysis only spans through 2012 due to data availability. Moreover, the initiative was intended to promote access to LARCs among low-income women in general and not just teenagers. As such, in order to provide a more complete understanding of the effects of the program it will be important for future work to revisit its effects once more data becomes available and to consider the effects on older women. It will also be important to consider the effects of expanding access to LARCs on sexual activity and reproductive health more generally. In addition, we note that our results suggest that future work considering the effects expanded

[19]This number is based on the estimated effect of 5% across 2009–2012, an average of 156,000 teen females living in Colorado counties with Title X clinics over these years, and a birth rate of 30 per 1,000 teen females during these years.

access to LARCs may provide useful insights into the effects of unintended pregnancies (or the prevention thereof) on long-run outcomes, such as educational attainment, earnings, and the use of social assistance programs.

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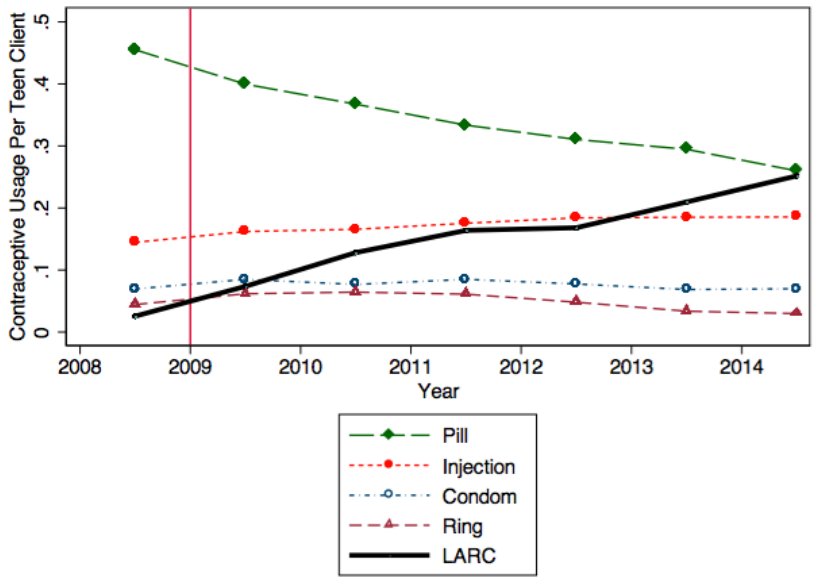
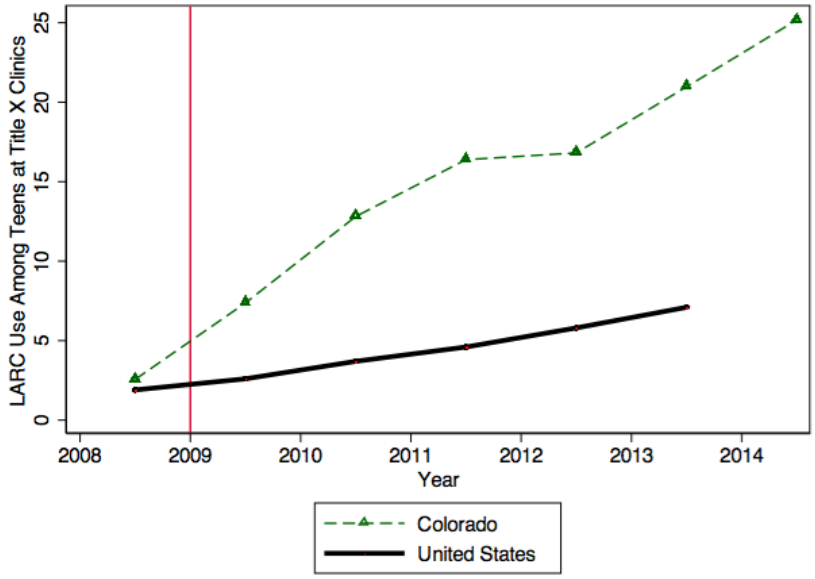
Figure 1
Primary Form of Contraceptive Used By Teens Visiting Title X Clinics in Colorado



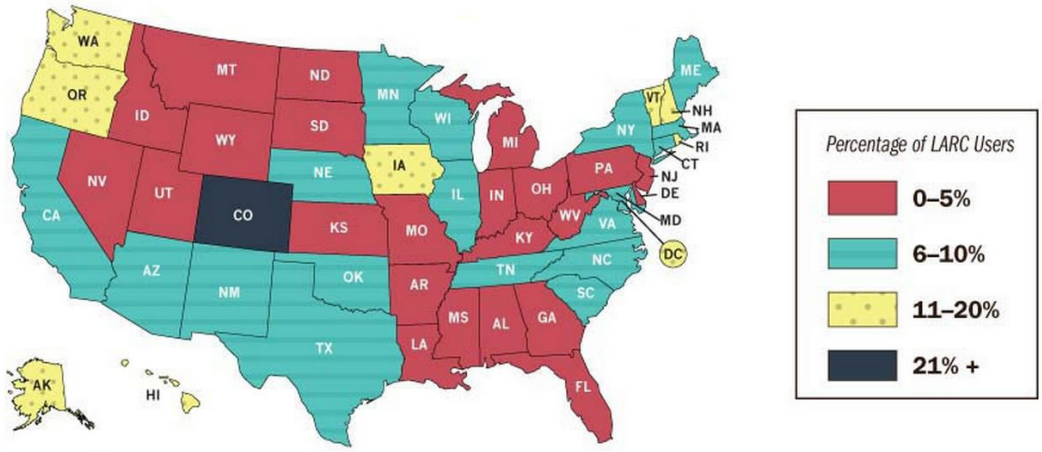
Notes: Authors' calculation based on annual data on Colorado Title X contraception usage by age and method provided by the Colorado Department of Public Health and Environment. The vertical line, drawn at 2009, represents the year Colorado's Family Planning Initiative was implemented.

Figure 2
LARC Use Among Teens Visiting Title X Clinics, Colorado Versus United States Overall



Notes: Numbers for Colorado are authors' calculation based on annual data on Colorado Title X contraception usage by age and method provided by the Colorado Department of Public Health and Environment. Numbers for the United States overall are taken from the Title X Family Planning Annual Report, United States 2013. Note that this figure shows LARC use in Colorado in 2014 for readers' information but the analysis of outcomes only extends through 2013. The vertical line, drawn at 2009, represents the year Colorado's Family Planning Initiative was implemented.

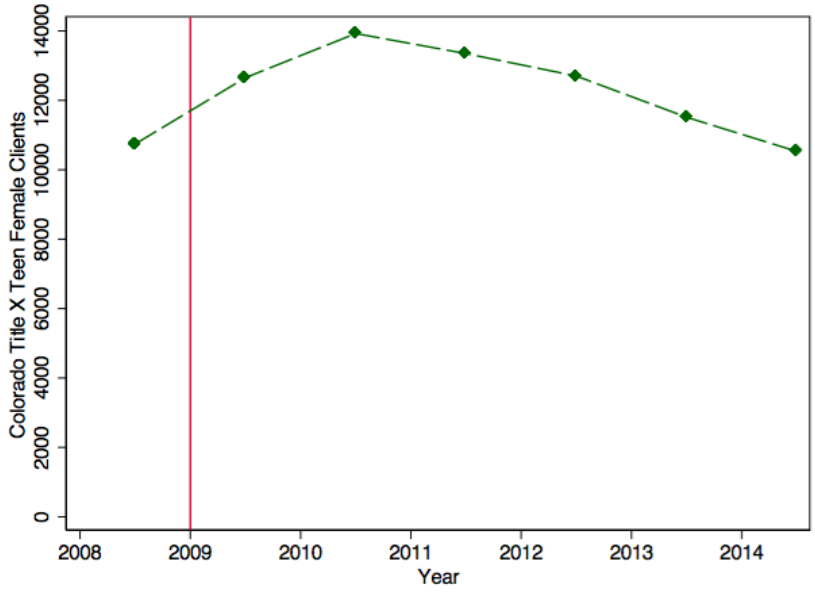
Figure 3
LARC Use Among Among Teens Visiting Title X Clinics by State, 2013



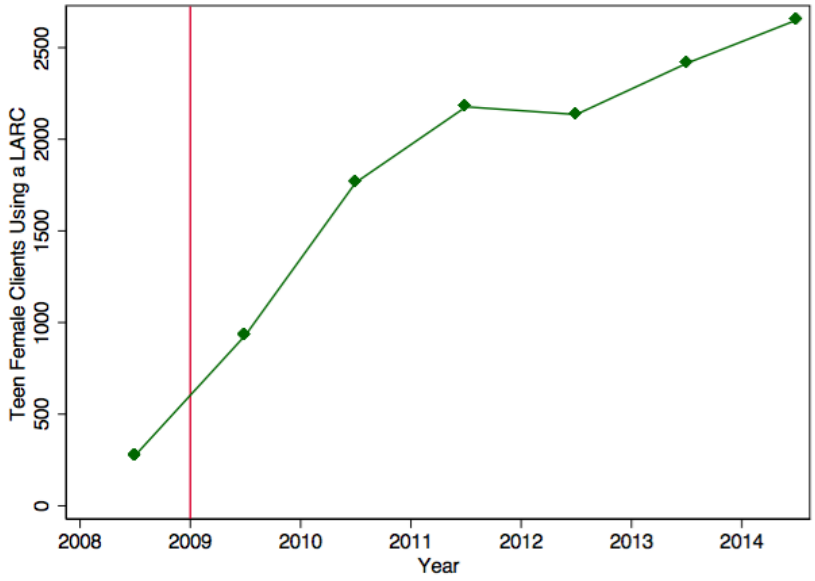
Source: Title X Family Planning Annual Report, United States 2013.

Figure 4
Teen Female Visitors to Colorado Title X Clinics Over Time

Panel A: Number of Visitors Overall

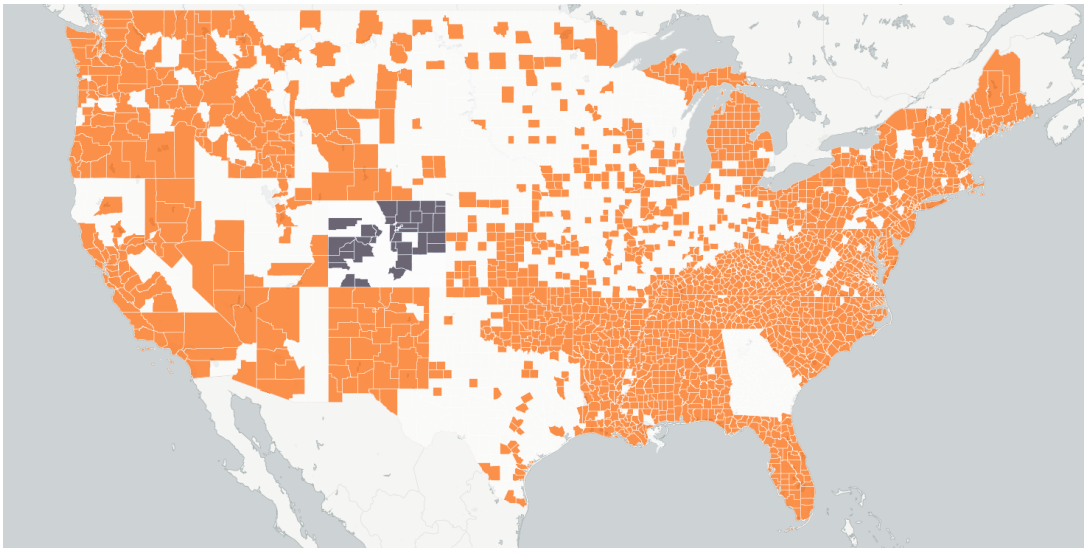


Panel B: Number of Visitors with a LARC as Their Primary Form of Contraception



Notes: Authors' calculation based on annual data on Colorado Title X clients and contraception usage by age and method provided by the Colorado Department of Public Health and Environment.

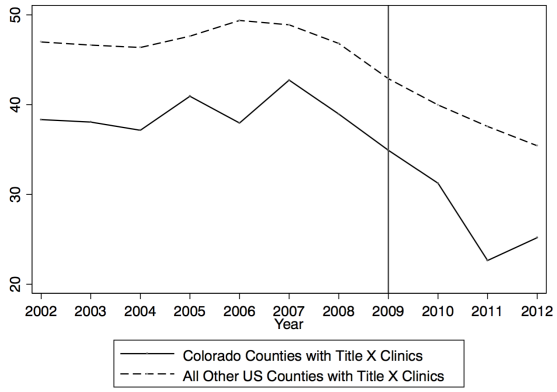
Figure 5
Counties With Title X Clinics



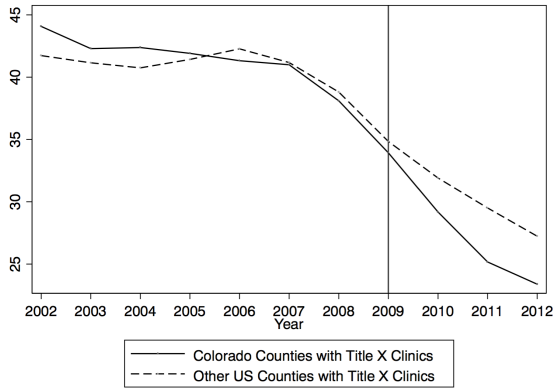
Notes: The above figure highlights counties that contain at least one Title X clinic as of 2009. The locations of Title X clinics in Colorado were obtained from Colorado's Department of Public Health and Environment?s Directory of Family Planning Services. Counties with Title X clinics outside of Colorado were identified by geocoding the addresses of such clinics listed in the US Department of Health and Human Service's 340B Database. Counties in navy represent counties with Title X clinics in Colorado.

Figure 6
Teen Birth Rates in Counties With Title X Clinics

Panel A: Simple Average Across Counties



Panel B: Weighted Average Across Counties (By Female Teen Population)



Notes: Teen birth rates—with births assigned to the year of conception based on the mother's last menstrual period—are constructed using the National Center for Health Statistics (NCHS), Division of Vital Statistics Natality Files and SEER population data. The vertical line represents the beginning of the Colorado Family Planning Initiative.

Table 1
Effectiveness of Various Methods of Contraception

Method	Typical Use	Perfect Use	Coverage Time
Sterilization*	99.9%	99.9%	Lifetime
Intrauterine Device*	99.9%	99.9%	3-12 years
Implant*	99.9%	99.9%	3 years
Injection	97%	99.9%	3 months
NuvaRing*	91%	99.7%	1 month
Oral Contraceptive	91%	99.7%	1 month
Patch	91%	99.7%	1 week
Condom	82%	98%	N/A
No Method	15%	15%	N/A

Note: * indicates methods funded by the Colorado Family Planning Initiative.

Table 2
Summary Statistics

	Colorado Counties *N=37*	**Comparison Counties** *N=2,219*
Pre-Treatment (2002-2008)		
Births per 1,000 females aged 15-19	39.16	47.53
Fraction Teens 15 Year-Olds	0.20	0.20
Fraction Teens 16 Year-Olds	0.21	0.20
Fraction Teens 17 Year-Olds	0.21	0.21
Fraction Teens 18 Year-Olds	0.20	0.20
Fraction Teens 19 Year-Olds	0.18	0.19
Fraction 15 Year-Olds Black	0.02	0.15
Fraction 16 Year-Olds Black	0.02	0.15
Fraction 17 Year-Olds Black	0.02	0.15
Fraction 18 Year-Olds Black	0.02	0.15
Fraction 19 Year-Olds Black	0.03	0.15
Fraction 15 Year-Olds Hispanic	0.20	0.08
Fraction 16 Year-Olds Hispanic	0.20	0.08
Fraction 17 Year-Olds Hispanic	0.20	0.08
Fraction 18 Year-Olds Hispanic	0.20	0.08
Fraction 19 Year-Olds Hispanic	0.22	0.09
Fraction 15 Year-Olds White	0.94	0.82
Fraction 16 Year-Olds White	0.95	0.82
Fraction 17 Year-Olds White	0.94	0.82
Fraction 18 Year-Olds White	0.94	0.82
Fraction 19 Year-Olds White	0.94	0.81
County Unemployment Rate	4.37	5.74
Post-Treatment (2009-2012)		
Births per 1,000 females aged 15-19	28.50	38.96
Fraction Teens 15 Year-Olds	0.20	0.20
Fraction Teens 16 Year-Olds	0.20	0.20
Fraction Teens 17 Year-Olds	0.21	0.20
Fraction Teens 18 Year-Olds	0.21	0.20
Fraction Teens 19 Year-Olds	0.19	0.20
Fraction 15 Year-Olds Black	0.03	0.15
Fraction 16 Year-Olds Black	0.03	0.15
Fraction 17 Year-Olds Black	0.03	0.15
Fraction 18 Year-Olds Black	0.03	0.15
Fraction 19 Year-Olds Black	0.04	0.16
Fraction 15 Year-Olds Hispanic	0.24	0.10
Fraction 16 Year-Olds Hispanic	0.23	0.10
Fraction 17 Year-Olds Hispanic	0.23	0.10
Fraction 18 Year-Olds Hispanic	0.24	0.10
Fraction 19 Year-Olds Hispanic	0.25	0.11
Fraction 15 Year-Olds White	0.93	0.81
Fraction 16 Year-Olds White	0.93	0.81
Fraction 17 Year-Olds White	0.93	0.81
Fraction 18 Year-Olds White	0.92	0.80
Fraction 19 Year-Olds White	0.92	0.80
County Unemployment Rate	7.44	9.35

Notes: Births are based on the National Center for Health Statistics (NCHS), Division of Vital Statistics Natality Files. They assigned to the year of conception based on the mother's reported last menstrual period. Population data, including race, ethnicity, and age are from SEER. Unemployment rates are from the BLS. Column 1 shows the means for treated counties in our sample, i.e., Colorado counties with a Title X clinic. Column 2 displays the means for the comparison counties, i.e., counties outside of Colorado with a Title X clinic.

Table 3
Poisson Estimates of the Effect of the Colorado Family Planning Initiative on Teen Birth Rates

	(1)	(2)	(3)	(4)
Effect of Initiative in First Year	-0.042	-0.063**	0.007	-0.000
	(0.032)	(0.028)	(0.017)	(0.017)
Effect of Initiative in Second Year	-0.103***	-0.110***	-0.041*	-0.043*
	(0.034)	(0.035)	(0.022)	(0.023)
Effect of Initiative in Third Year	-0.170***	-0.174***	-0.096***	-0.095***
	(0.037)	(0.041)	(0.026)	(0.030)
Effect of Initiative in Fourth Year	-0.163***	-0.159***	-0.076**	-0.070
	(0.051)	(0.054)	(0.037)	(0.043)
Average effect	-0.120	-0.127	-0.051	-0.052
P-value (test average effect = 0)	0.001	0.001	0.020	0.039
Average effect in years 2-4	-0.146	-0.148	-0.071	-0.070
P-value (test average effect in years 2-4 = 0)	0.000	0.000	0.005	0.019
County Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Economic and Demographic Controls	No	Yes	No	Yes
State Linear Time Trends	No	No	Yes	Yes

Notes: Estimates are based on annual data for 2,256 counties from 2002–2012. Births are assigned to the year of conception based on the mother's reported last menstrual period. The control for economic conditions is the county unemployment rate and demographic control variables include percent of teens who are black, percent of teens who are Hispanic, the fraction of teens by age and race. Robust standard errors clustered at the county level are shown in parentheses.
*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Table 4
Poisson Estimates of the Effect of the Colorado Family Planning Initiative on Teen Birth Rates, By County Poverty Rates

	Poverty Rate > CO Median		Poverty Rate ≤ CO Median	
	(1)	(2)	(3)	(4)
Effect of Initiative in First Year	0.003	-0.007	0.012	-0.001
	(0.019)	(0.017)	(0.030)	(0.030)
Effect of Initiative in Second Year	-0.052***	-0.062***	-0.027	-0.027
	(0.016)	(0.016)	(0.043)	(0.044)
Effect of Initiative in Third Year	-0.108***	-0.126***	-0.072*	-0.059
	(0.033)	(0.035)	(0.039)	(0.041)
Effect of Initiative in Fourth Year	-0.094**	-0.109**	-0.040	-0.022
	(0.042)	(0.049)	(0.059)	(0.060)
Average effect	-0.063	-0.076	-0.032	-0.027
P-value (test average effect = 0)	0.004	0.002	0.414	0.497
Average effect in years 2-4	-0.085	-0.099	-0.046	-0.036
P-value (test average effect in years 2-4 = 0)	0.002	0.001	0.286	0.421
County Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Economic and Demographic Controls	No	Yes	No	Yes
State Linear Time Trends	Yes	Yes	Yes	Yes

Notes: Estimates in columns 1 and 2 are based on annual data from 2002–2012 for 1649 counties while the estimates in columns 3 and 4 are based are based on annual data from 2002–2012 for 607 counties. Births are assigned to the year of conception based on the mother's reported last menstrual period. The control for economic conditions is the county unemployment rate and demographic control variables include percent of teens who are black, percent of teens who are Hispanic, the fraction of teens by age and race. Robust standard errors clustered at the county level are shown in parentheses.

*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Table 5
Including Lead Terms for
Poisson Estimates of the Effect of the Colorado Family Planning Initiative on Teen Birth Rates

	(1)	(2)	(3)	(4)
Panel A: All Counties				
Effect of Initiative in First Year	-0.000	0.003	0.016	-0.016
	(0.017)	(0.021)	(0.032)	(0.041)
Effect of Initiative in Second Year	-0.043*	-0.040	-0.025	-0.061
	(0.023)	(0.026)	(0.036)	(0.044)
Effect of Initiative in Third Year	-0.095***	-0.091***	-0.074	-0.116*
	(0.030)	(0.032)	(0.048)	(0.061)
Effect of Initiative in Fourth Year	-0.070	-0.066	-0.046	-0.093
	(0.043)	(0.042)	(0.062)	(0.070)
One Year Before Initiative		0.005	0.016	-0.010
		(0.016)	(0.019)	(0.031)
Two Years Before Initiative			0.016	-0.005
			(0.022)	(0.028)
Three Years Before Initiative				-0.026
				(0.018)
Average effect	-0.052	-0.048	-0.032	-0.071
P-value (test average effect = 0)	0.039	0.072	0.451	0.173
Average effect in years 2-4	-0.070	-0.066	-0.048	-0.090
P-value (test average effect in years 2-4 = 0)	0.019	0.032	0.310	0.115
Panel B: Counties with Poverty Rate > CO Median				
Effect of Initiative in First Year	-0.007	0.002	0.002	-0.040
	(0.017)	(0.019)	(0.031)	(0.043)
Effect of Initiative in Second Year	-0.062***	-0.052***	-0.051	-0.101**
	(0.016)	(0.019)	(0.032)	(0.051)
Effect of Initiative in Third Year	-0.126***	-0.114***	-0.114**	-0.170**
	(0.035)	(0.031)	(0.052)	(0.070)
Effect of Initiative in Fourth Year	-0.109**	-0.096**	-0.095	-0.159*
	(0.049)	(0.039)	(0.069)	(0.081)
One Year Before Initiative		0.015	0.015	-0.020
		(0.022)	(0.024)	(0.039)
Two Years Before Initiative			0.000	-0.028
			(0.028)	(0.032)
Three Years Before Initiative				-0.035
				(0.025)
Average effect	-0.076	-0.065	-0.065	-0.117
P-value (test average effect = 0)	0.002	0.001	0.131	0.044
Average effect in years 2-4	-0.099	-0.087	-0.087	-0.143
P-value (test average effect in years 2-4 = 0)	0.001	0.000	0.075	0.028
Panel C: Counties with Poverty Rate ≤ CO Median				
Effect of Initiative in First Year	-0.001	-0.005	0.022	-0.008
	(0.030)	(0.040)	(0.055)	(0.068)
Effect of Initiative in Second Year	-0.027	-0.032	-0.001	-0.036
	(0.044)	(0.051)	(0.062)	(0.065)
Effect of Initiative in Third Year	-0.059	-0.065	-0.029	-0.069
	(0.041)	(0.054)	(0.074)	(0.088)
Effect of Initiative in Fourth Year	-0.022	-0.028	0.012	-0.033
	(0.060)	(0.071)	(0.089)	(0.094)
One Year Before Initiative		-0.008	0.014	-0.011
		(0.020)	(0.033)	(0.048)
Two Years Before Initiative			0.033	0.013
			(0.025)	(0.039)
Three Years Before Initiative				-0.025
				(0.026)
Average effect	-0.027	-0.033	0.001	-0.036
P-value (test average effect = 0)	0.497	0.520	0.986	0.633
Average effect in years 2-4	-0.036	-0.042	-0.006	-0.046
P-value (test average effect in years 2-4 = 0)	0.421	0.450	0.937	0.565
County Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Economic and Demographic Controls	Yes	Yes	Yes	Yes
State Linear Time Trends	Yes	Yes	Yes	Yes

Notes: Estimates are based on annual data from 2002–2012 for 2,256 counties in Panel A, 1649 counties In Panel B, and 607 counties in Panel C. Births are assigned to the year of conception based on the mother's reported last menstrual period. The control for economic conditions is the county unemployment rate and demographic control variables include percent of teens who are black, percent of teens who are Hispanic, the fraction of teens by age and race. Robust standard errors clustered at the county level are shown in parentheses.

*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.

Table 6
WLS Estimates of the Effect of the Colorado Family Planning Initiative on Teen Birth Rates

	All Counties		Poverty Rate > CO Median		Poverty Rate ≤ CO Median	
	(1)	(2)	(3)	(4)	(5)	(6)
Effect of Initiative in First Year	0.007	0.000	-0.013	-0.012	0.014	0.011
	(0.025)	(0.025)	(0.017)	(0.019)	(0.037)	(0.039)
Effect of Initiative in Second Year	-0.031	-0.034	-0.064***	-0.061***	-0.018	-0.019
	(0.031)	(0.030)	(0.019)	(0.017)	(0.046)	(0.047)
Effect of Initiative in Third Year	-0.080**	-0.082***	-0.121***	-0.108***	-0.060	-0.063
	(0.033)	(0.031)	(0.043)	(0.040)	(0.043)	(0.045)
Effect of Initiative in Fourth Year	-0.053	-0.054	-0.103*	-0.085	-0.028	-0.033
	(0.047)	(0.046)	(0.057)	(0.054)	(0.062)	(0.065)
Average effect	-0.039	-0.042	-0.075	-0.066	-0.023	-0.026
P-value (test average effect = 0)	0.190	0.144	0.011	0.014	0.582	0.552
Average effect in years 2-4	-0.055	-0.057	-0.096	-0.085	-0.035	-0.038
P-value (test average effect in years 2-4 = 0)	0.097	0.073	0.009	0.011	0.433	0.411
County Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Economic and Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
State Linear Time Trends	Yes	n/a	Yes	n/a	Yes	n/a
County Linear Time Trends	No	Yes	No	Yes	No	Yes

Notes: Weighted least squares estimates—with cells weighted by the population of female teens—are based on annual data from 2002–2012. The estimates in columns 1 and 2 are based on 2,256 counties, the estimates in columns 3 and 4 are based on 1,649 counties, and the estimates in columns 5 and 6 are based on 607 counties. Births are assigned to the year of conception based on the mother's reported last menstrual period. The outcome variable is the natural log of the teen births in a county year (plus one) divided by the population of female teens. The control for economic conditions is the county unemployment rate and demographic control variables include percent of teens who are black, percent of teens who are Hispanic, the fraction of teens by age and race. Robust standard errors clustered at the county level are shown in parentheses.

*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively.