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RESEARCH ARTICLE

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Subdermal contraceptive implants and repeat teenage motherhood: Evidence from a major maternity hospital-based program in Uruguay

Zuleika Ferre[1] | **Patricia Triunfo**[1] | **José-Ignacio Antón**[2]

[1]University of the Republic, Montevideo, Uruguay

[2]University of Salamanca, Salamanca, Spain

Correspondence
José-Ignacio Antón.
Email: janton@usal.es

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Abstract

Teenage fertility is a social problem because of its private and public costs in countries of different development levels. Reductions in adolescent birth rates do not necessarily follow drops in overall fertility due to the demographic transition model. This paper analyses the impact of a subdermal contraceptive program on repeat teenage motherhood. Using a regression discontinuity design, we find that the intervention reduced mothers' likelihood of having another child in the next 48 months by 10 percentage points. This reduction is not random, and we also identify small positive selection in subsequent births.

KEYWORDS
contraceptive methods, fertility, subdermal implants, teenage fertility, Uruguay

JEL CLASSIFICATION
I12, I18, J13, J18

1 | INTRODUCTION

Uruguay was one of the first countries in Latin American and the Caribbean to undergo a demographic transition. Its total fertility rate (TFR) reached 2.9 children per woman in 1960–1965, very close to the European TFR, with a relatively high adolescent fertility rate (AFR) of 63 children per thousand female adolescents between 15 and 19 years old, considerably higher than that in Europe (37) but lower than that in the United States (82). The following decades witnessed a decoupling of the two indicators. While the TFR experienced a pronounced drop, the AFR remained stable. Since 2016, the latter has substantially declined, reaching 28 births per thousand adolescents aged 15–19 in 2020. This constitutes a milestone in Uruguayan demographics (Cabella et al., 2019).

Teenage motherhood is a problematic phenomenon and an important public health matter for nations of different development levels. A sizable number of works have extensively documented its association with poor social, health and economic outcomes for both parents and children (Aizer et al., 2022; Boden et al., 2007; Branson & Byker, 2018; Duncan et al., 2018; Engelhardt & Prskawetz, 2004; Francesconi, 2008; Hoffman & Maynard, 2008; Johansen et al., 2020; Rodríguez Vignoli et al., 2017; Varela Petito, 2004; Varela Petito et al., 2014). Although the literature is still scarce and focused mainly on the United States, several studies show the effectiveness of expanding family planning clinics in reducing adolescent pregnancy (Branson & Byker, 2018; Kelly et al., 2020; Strupat, 2017) and expanding access to long-acting reversible contraception (LARC) (Ceni et al., 2021; Lindo & Packham, 2017; Luca et al., 2021) and short-acting methods (Ananat & Hungerman, 2012;

Bailey, 2006; Bentancor & Clarke, 2017; Guldi, 2008) such as subcutaneous implants and intrauterine devices and the pill or the morning-after pill, respectively.

In addition, while the effects of abortion legalization on adolescent fertility seem ambiguous (Angrist & Evans, 2000; Clarke & Mühlrad, 2021; Levine et al., 1999), the impact of abstinence-based education programmes is apparently null (Carr & Packham, 2017; Fox et al., 2019; Kearney & Levine, 2015). Regarding contraceptive methods, cohort studies point out the greater efficacy, adherence and satisfaction of LARC methods than of short-acting contraception among adolescents (American College of Obstetricians and Gynecologists, 2018; Arribas-Mir et al., 2009; Diedrich et al., 2017; Raine et al., 2011; Rosenstock et al., 2012; Short et al., 2011). However, though adoption of the former has increased remarkably in the last decade, they remain much less used than the latter (Finer et al., 2012; Gomez Ponce de Leon et al., 2019; Luca et al., 2021).

This paper analyses the impact of a subdermal contraceptive implant program on repeat teenage motherhood in Uruguay from November 2015 to December 2016. The intervention was carried out by the country's largest maternity unit, which offered a subdermal implant after an obstetric event to mothers under 20 years old. This long-term birth control method consists of placement of a small flexible plastic rod (about the size of a matchstick or hairpin) under the skin in a woman's upper arm. The device releases the hormone progestogen into the bloodstream, which prevents women from becoming pregnant. With a duration of up to 5 years, the effectiveness of this method is above 99%. We make use of hospital administrative data of the universe of births and employ a regression discontinuity design (RDD) that exploits the reduction in the likelihood of receiving an offer of an implant among mothers above the age cut-off of 20 years old. We find that the program reduced mothers' probability of having another child in the next 48 months by 10 percentage points. This intention-to-treat (ITT) effect implies an approximately one-third decrease in the fertility rate of the corresponding group before the hospital implemented the program. Our results hold in a number of robustness checks in which we consider different model specifications and placebo tests.

To the best of our knowledge, this work is the first to address the effects of this specific type of postpartum intervention. It also widens the empirical evidence, which we discuss in detail in the next section, on the effectiveness of public health interventions in curbing adolescent fertility, particularly outside high-income economies.

The rest of the paper unfolds as follows. Section 2 discusses the previous literature and frames our work within it. Section 3 discusses our research design, including the institutional setting, data and empirical strategy. Section 4 presents the results of our analyses and discusses their external validity. Section 5 summarizes and discusses the main implications of the research.

2 | BACKGROUND AND RELATED LITERATURE

The empirical evidence regarding the effectiveness of different strategies for reducing teenage motherhood is ambiguous. The outcomes of the strategies vary by both the type of program/birth control method and the context of implementation. Several studies (Ananat & Hungerman, 2012; Bailey, 2006; Guldi, 2008) examine the effects of the availability of the first contraceptive pill (Enovid) in the US, authorized in 1960 by the Food and Drug Administration (FDA). The pill was revolutionary not only because of its greater effectiveness compared to that of other existent contraceptive methods but also because it prevented conception from the moment of intercourse. The studies find that the pill's availability had a negative impact on young women's fertility in the United States (Ananat & Hungerman, 2012; Bailey, 2006; Guldi, 2008).

The evidence on the impact of abortion legalization is mixed. The results of this literature range from findings of no effect to evidence of reductions of 13 percentage points in teenage motherhood (Angrist & Evans, 2000; Antón et al., 2018; Levine et al., 1999). A lack of consensus also applies to the relevance of laws that restrict minors' access to voluntary termination of pregnancy (Bitler & Zavodny, 2001; Joyce et al., 2006; Joyce & Kaestner, 1996; Levine, 2003; Myers & Ladd, 2020).

Several studies explore the effects of access to free emergency contraception (such as Prevent, approved by the FDA in 1997, which in most states required a prescription until 2006). Durrance (2013) and Gross et al. (2013) provide empirical evidence suggesting negligible effects on adolescent fertility and an increase in sexually transmitted diseases. In Chile, which used to have one of the most restrictive abortion laws in the world, the introduction of emergency contraception reduced teenage birth rates by 1.5–3 percentage points (Bentancor & Clarke, 2017). This larger effect in Chile than in countries with more liberal laws suggests a certain degree of substitution between abortion and emergency contraception.

Compared to alternatives that require user intervention (such as condoms or contraceptive pills), LARC methods—the use and accessibility of which have increased in recent years—have proved highly effective in preventing pregnancy. Several studies on the United States document sizable reductions in teenage fertility rates—particularly in poor areas—as a result of the expansion of family planning facilities offering counseling, access to contraception and referrals to social services (Kelly et al., 2020; Lindo & Packham, 2017; Luca et al., 2021; Packham, 2017). In an experimental evaluation, Luca et al. (2021), like us, focus on repeat adolescent pregnancy. They find that a comprehensive intervention targeted at teenagers and comprising

LARCs reduced repeat pregnancy by half, with one-third of this effect being due to the increase in access to these types of contraceptive methods through the program.

Although scarcer, empirical evidence from outside high-income economies is quite supportive of these kinds of broad strategies. Recent literature confirms the success of policies that combine family planning, counseling and access to LARCs in reducing teenage fertility in South Africa (Branson & Byker, 2018), with even intergenerational benefits detected in Indonesia (Strupat, 2017) and Ecuador (Galárraga & Harris, 2021). In contrast to such comprehensive programmes, the abstinence-based programmes created by several US states and targeted at adolescents have yielded, at best, null impacts on pregnancy and abortion rates and the prevalence of sexually transmitted diseases (Carr & Packham, 2017; Fox et al., 2019; Kearney & Levine, 2015).

Last, the evidence of the impact of different policies on adolescent fertility in Uruguay is scarce. Antón et al. (2018) find an 8% reduction in unplanned births in the short run as a result of abortion legalization. While these authors find no impact on teenagers, the work of Cabella and Velázquez (2022) suggests that the decriminalization of voluntary interruption of pregnancy would have reduced the adolescent birth rate by 4%. Ceni et al. (2021), using an event study and exploiting the timing of the rollout and regional differences in the availability of subcutaneous implants at state-owned hospitals, show that the theoretical possibility of accessing this contraceptive method through public health care led to an overall reduction of 3 percentage points in the birth rate of teens and women covered by this health system. This decline was notably high among adolescents and nulliparous women.

3 | RESEARCH DESIGN

3.1 | Institutional setting

The backbone of the Uruguayan health care system is a public national health insurance program that ensures universal coverage through the combination of public and private production of services (Balsa & Triunfo, 2021). Residents can choose between the two types of providers, and 39% were covered by the former in December 2021 (Ministerio de Salud Pública, 2022b). Mobility between the two kinds of delivery systems is rare and subject to certain restrictions (e.g., overall, one cannot switch providers before a lapse of 2 years).

Uruguay included subcutaneous implants within the publicly funded basket of contraceptive methods at the end of 2014, but they became available only at hospitals in the public network. Several follow-up and satisfaction surveys show the method had a high acceptance rate, a low failure rate (2.5 cases per 1000 users) and a high continuity rate (92%) (Aguirre et al., 2017; Tristant et al., 2019). The Ministry of Public Health initially paid around US$ 10 for each device (as part of a large batch). To date, access to the implants, including their placement, has been free for Uruguayan women. For the hospital, the cost, corresponding to the wage of a public sector specialist practitioner for the time it takes to advise the patient about the procedure and place the device, is approximately US$ 8 (Sindicato Médico del Uruguay, 2022). Therefore, at most, the overall fiscal cost of the procedure is approximately US$ 18 per unit.

Located in the capital city (Montevideo), Pereira Rossell Hospital Center (CHPR by its Spanish acronym) is part of the network of public care centers and hosts the largest maternity unit in Uruguay. According to hospital birth records (Ministerio de Salud Pública, 2022a), in 2014, it concentrated approximately 15% and 40% of births in the country and in the public system, respectively. CHPR treats mainly the low-income population. Therefore, it is unsurprizing that the educational attainment of people giving birth there is substantially lower than average—in 2014, only 26% of women giving birth at the center had completed lower secondary school, relative to the national average of 70% among new mothers overall—or that almost 25% of Uruguayan mothers aged less than 20 years old had their children at the hospital.

From November 1, 2015 to December 31, 2016, CHPR developed a free program offering post-obstetric gestagen subdermal implant placements in the hospital's adolescent postpartum ward. This room accommodated mothers under 20 years old, but its patients could occasionally include older mothers depending on hospital needs (e.g., lack of space in other wards). The intervention aimed at providing counseling on family planning and offering implants of the contraceptive method within the first 48 h after an abortion, childbirth or caesarean section and before hospital discharge. In 2017, the program changed, expanding to other population groups. According to Lacerda et al. (2019), who did a follow-up survey of postpartum adolescents who opted for the implants between November 2015 and December 2016 and between January 2018 and January 2019, participants reported high levels of satisfaction (76%) and adherence to the method (97%), although only 15% declared no adverse effects (with the main reported side effects being amenorrhea and irregular menstrual bleeding).

3.2 | Data

In our empirical analysis, we use administrative data from the Perinatal Information System (SIP by its Spanish acronym) (Ministerio de Salud Pública, 2022a), a birth register with virtually universal coverage across Uruguay that contains detailed information on newborns, pregnancies and mothers (Diaz-Rossello, 1998; Simini, 1999; World Health Organization, 2010). It draws data from clinical forms filled out by health care professionals and is commonly used in gynecology and neonatology. We focus on births between November 1, 2015 and December 31, 2016, the program's period of operation. Our analysis also considers births in the interval November 1, 2013–December 31, 2014 for one of the robustness checks.

Due to the collaboration of health professionals at CHPR, we can match mothers who gave birth at the institution during the period of interest with information on subdermal implants provided by the maternity ward while the program was running. As we argue below, receiving an implant is a policy outcome, but we use this information to discuss the strength of our identification strategy in isolating the effects on teenage fertility. Given that the target of this action was women giving birth under 20 years old, we look at a 60-month interval centered on the date of the 20th birthday.

Our main variable of interest is fertility after the eventual implant offer. Therefore, we explore how mothers who were more likely to receive an offer because they were below the age cut-off compare with those who were less likely to have access to subdermal implants as they were older than 20. We take advantage of the longitudinal nature of the database to assess the former group's probability of having another child in the next 48 months after receiving the offer of the contraceptive implant. This is the longest period that we can cover at the time of writing of this paper. As a result, the available sample for our baseline analysis comprises 2755 mothers. We present the main descriptive statistics of the variables considered in the empirical exercise in the appendix (Table A1).

It is worth highlighting that repeat motherhood among teenagers is common in Uruguay. Almost 44% of mothers aged less than 20 years who gave birth in 2014 (the year before the program started) had another child in the following 4 years (Ministerio de Salud Pública, 2022a).

3.3 | Empirical strategy

For our empirical strategy, we use an RDD that exploits the fact that the program targeted women below 20 years old. As explained above, sometimes women above the age threshold were allocated into the adolescent postpartum ward, where the subdermal implant was offered. This means that some women above the cut-off point were exposed to the treatment (i.e., offered the implant) and even received the implant. Consequently, the discontinuity is not sharp, but the probability of being offered the implant is substantially higher for mothers below the age threshold.

Moreover, we cannot observe who actually was able to receive the implant. We can only verify whether a new mother belongs to the theoretical target group (i.e., if she was less than 20 years old at the time of delivery). Consequently, we can estimate an ITT effect at the local level based on the mentioned age cut-off point. Note that the installation of the subcutaneous implant does not represent the treatment but an outcome. If we abstract from removals or failures, installation of this contraceptive device, which is more than 99% effective, almost mechanically implies null fertility during the implant duration.[1]

We also do not know which women received counseling from the staff (as explained above, an ingredient of the specific intervention). In principle, even if we cannot separate the effect of the implant from that of such counseling, this issue is not problematic: it simply means that the latter is part of the program. It is worth mentioning that contraception is widely available in the country. The Uruguayan health authorities heavily subsidize access to several methods, and the morning-after pill and abortion were legal by the time the intervention began. Subdermal implants even started to be available in the public health sectors (through primary care) at approximately the same time that the CHPR deployed the program. Again, this does not interfere with our research design since we are not assessing the impact of the availability of implants but rather the effects of a very specific postpartum intervention comprising them. The availability of other birth control methods is indeed relevant, but it is part of the context in which the program was implemented. In the results section, we discuss how these context-related issues might affect the external validity of our findings.

To estimate the ITT effect, we focus on mothers whose age was slightly less and slightly more than 20 years old (the cut-off point) when they gave birth, that is, between November 1, 2015 and December 31, 2016, the period when the program ran. The main outcome of interest O_i is fertility, specifically a binary indicator equal to one if the mother gave birth to another child in

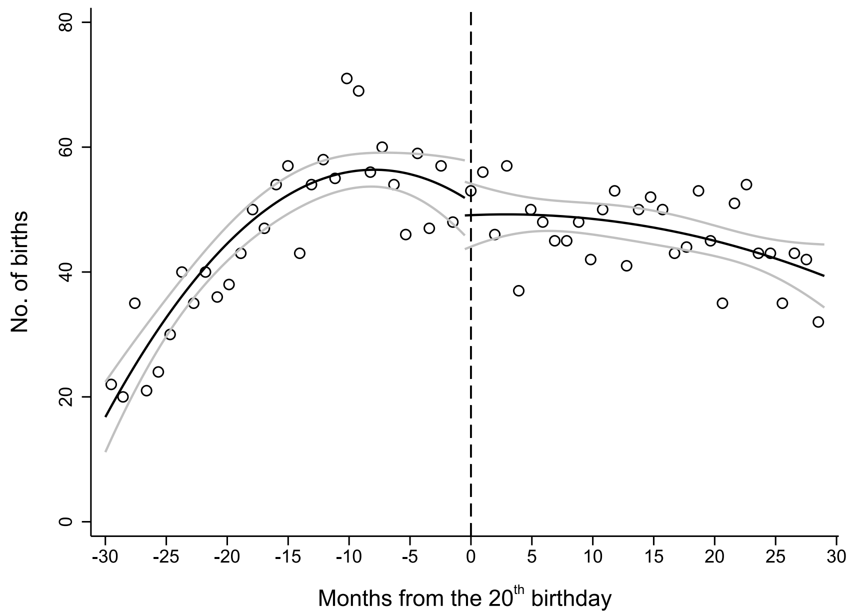

FIGURE 1 Number of births per month by months from 20th birthday. The figure shows the number of births around the cut-off of 20 years old when mothers could have received the implant offer. We estimate a quadratic separately at both sides of the cut-off. Gray lines are point-wise 90% confidence intervals. *Source*: Authors' analysis from SIP. [Colour figure can be viewed at wileyonlinelibrary.com]

the 48 months following the implant offer. The explanatory variable of primary interest is T_i, a dummy variable equal to one if the mother's age (A_i) at the time of birth was below 20 years (c).

We estimate the ITT by ordinary least squares through the following regression:

$$O_i = \beta_0 + \beta_1 T_i + \beta_2 (A_i - c) + \beta_3 (A_i - c)^2 + \beta_4 (A_i - c) \times T_i + \beta_5 (A_i - c)^2 \times T_i + \Theta X_i + \varepsilon_i. \tag{1}$$

We allow for different quadratic time trends in age (second-order polynomials) before and after the birthday cut-off and control for a set of covariates on the mother's sociodemographic characteristics and observable birth outcomes when the implant was eventually offered (X_i). The latter include marital status, education, parity, gestation length, Apgar score at 1 minute, number of prenatal controls and month fixed effects. The parameter of interest is β_1, which tells us the effect of being below the cut-off point on the outcome of interest. Our main specification considers mothers who gave birth during the period when the program was running over the 30 months before and after they reached 20 years old.

The source of identification of the policy's ITT effect is the reduction in new mothers' likelihood of receiving an implant offer after the 20-year-old cut-off is crossed. In other words, the policy application will be as good as randomized in the neighborhood around the discontinuity threshold if the research design satisfies certain conditions. The first condition is that there must not be any manipulation of the forcing variable by mothers. This is extremely unlikely in our set-up as the program neither was public nor benefited from advertising. Furthermore, even in the improbable case that mothers were aware of the program, it is hard to imagine that women in the private sector would have moved to the public network to receive the implant if we bear in mind the costs of teenage motherhood and the costs of this procedure.

Regarding the first condition, if fertility sharply changed at the cut-off point, this would indicate that some sort of manipulation must be going on, with some selection process in place that threatened the validity of our research design. This is not the case here. We find that the average number of births per month does not vary around the cut-off (Figure 1). We also perform the density test suggested by McCrary (2008), the result of which does not allow us to reject the hypothesis that there is no shift at the 20-year-old threshold (p-value = 0.312).

The second condition is that there not be any correlation between an observation's being below the cut-off point and the factors affecting the outcome. We assess whether there is any discontinuity in the average values of the observable covariates through the lens of the specification outlined above. They correspond to pre-treatment characteristics since they pertain to mothers' demographic and socioeconomic characteristics and birth outcomes before the implant was offered. We do not find any evidence of a shift in these predetermined characteristics at the relevant age threshold (Table 1). We also carry out the permutation test suggested by Canay and Kamat (2017) and arrive at the same conclusion (p-values of 0.662, 0.397, 0.844, 0.454, 1.000, 0.657 and 0.671 for each of the seven variables in Table 1, respectively). Therefore, we have no reason to expect any discontinuity in the relevant unobservable factors at the cut-off.

TABLE 1 Covariate balance: Evaluation of the discontinuity in the covariates at the cut-off.

	(I) Lower secondary and above	(II) Single mother	(III) Higher-order birth	(IV) Pre-term birth	(V) Apgar score at 1 min.	(VI) Birth weight	(VII) No. of prenatal controls
Intention to treat (age <20)	−0.012	0.072	0.073	0.028	0.143	24.799	−0.038
	(0.052)	(0.051)	(0.053)	(0.033)	(0.169)	(67.606)	(0.372)
Quadratic form	✓	✓	✓	✓	✓	✓	✓
Interaction	✓	✓	✓	✓	✓	✓	✓
No. of observations	2755	2755	2755	2755	2755	2755	2755
Mean of dependent variable	0.317	0.285	0.372	0.263	0.107	3180	7.886

Note: Robust standard errors are in parentheses. The model includes only mothers who gave birth between 30 months before and 30 months after their 20th birthday. All the variables refer to the time of the birth when the mother could have received the implant offer.

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source: Authors' analysis from SIP.

TABLE 2 Effects on the probability of receiving a subdermal implant after giving birth.

	(I)	(II)	(III)
Intention to treat (age <20)	0.077**	0.074*	0.078**
	(0.039)	(0.039)	(0.039)
Quadratic form	✓	✓	✓
Interaction	✓	✓	✓
Controls		✓	✓
Month fixed effects			✓
No. of observations	2755	2755	2755
Mean of dependent variable	0.157	0.157	0.157

Note: The estimated coefficients reflect the change in the probability of receiving a subdermal implant from November 1, 2015 to December 31, 2016. Robust standard errors are in parentheses. The model includes only mothers who gave birth between 30 months before and 30 months after their 20th birthday.

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source: Authors' analysis from SIP.

Moreover, we can check whether being younger than 20 affects the probability of receiving an implant. Otherwise, we should not expect any negligible nonspurious effect on fertility. Reassuringly, using the specification in Equation (1), we find that being below the threshold raises the likelihood of receiving an implant by approximately 8 percentage points (Table 2).[2]

In the next section, jointly with the main results, we present two further analyses. First, if the program of subdermal implants is successful in lowering fertility, it is important to investigate whether the average quality of subsequent births increases. The reduction in the number of births might not be random; that is, subdermal implants could prevent pregnancies with potentially worse outcomes. Several studies document this mechanism in the case of abortion legalization. To explore this issue, we focus on the quality of subsequent births. We use Equation (1), replacing fertility (our left-hand-side variable) with different outcomes of those births that occurred after exposure to the implant offer.

We also show the results of several robustness checks. First, we compute the ITT using local linear and quadratic regression. Second, we check the sensitivity of our findings to the use of wider and narrower time intervals around the threshold of 20 years old. Last, we assess the impact of two different placebo interventions: first, we estimate the effect of mothers being below 20 years old one year before the program started (November 1, 2013–December 31, 2014), and second, we look at the impact of mothers being below the threshold at private hospitals (where subdermal implants were not available until several years later) during the same time window in which the program ran at CHPR.

4 | RESULTS

We present our estimation results in four steps. We first discuss the effects of mothers' being below the age cut-off (i.e., the ITT effect) on their fertility. We next focus on the impact of the program across different groups of mothers and then investigate

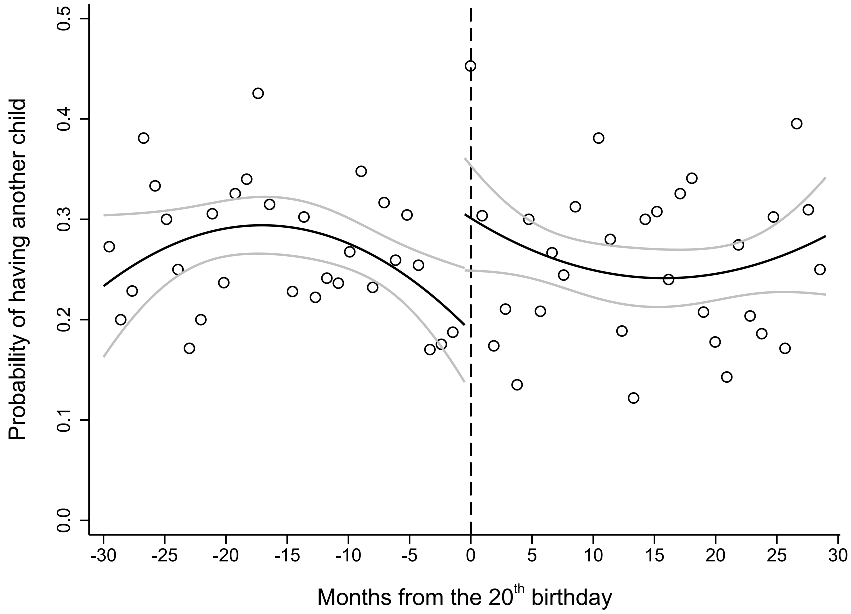

FIGURE 2 Effect on mothers' probability of having another child in the next 48 months after giving birth by months from 20th birthday. The figure shows women's probability of having another child in the next 48 months after the birth when they could have received an implant offer. We estimate a quadratic separately at both sides of the cut-off. Gray lines are point-wise 90% confidence intervals. *Source*: Authors' analysis from SIP. [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Effects on women's probability of having another child in the next 48 months after giving birth.

	(I)	(II)	(III)
Intention to treat (age <20)	−0.113**	−0.104**	−0.102**
	(0.048)	(0.048)	(0.048)
Quadratic form	✓	✓	✓
Interaction	✓	✓	✓
Controls		✓	✓
Month fixed effects			✓
No. of observations	2755	2755	2755
Mean of dependent variable	0.263	0.263	0.263

Note: The estimated coefficients reflect the change in the probability of having another child 48 months after the birth when the mother could have received the implant offer. Robust standard errors are in parentheses. The model includes only mothers who gave birth between 30 months before and 30 months after their 20th birthday.

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source: Authors' analysis from SIP.

whether there is any selection of subsequent births on observables due to the decrease in fertility. Last, we show the results of several robustness checks that include two placebo tests.

Figure 2, which allows for different quadratic trends before and after 20 years, suggests that the program reduced fertility in the subsequent 48 months by approximately 10 percentage points.[3]

Table 3 summarizes the findings of the econometric analysis, which confirm the graph's results. Column 1 corresponds to the graphical analysis, whereas the second model adds control covariates and the third includes month fixed effects. The results confirm those shown in the figure, that is, a reduction of 10 percentage points in mothers' likelihood of having another child in the following 4 years after giving birth. This is a sizable decrease in fertility. The probability of similar mothers in 2014, the year before the program started, having another child in the next 48 months after giving birth was 32.7%. Thus, the program cut fertility by nearly one-third.

Using seemingly unrelated regression techniques, we cannot reject that this estimate (in absolute value) and the rate of adoption of implants (shown in Table 1) are statistically different. One could in principle expect that the latter would be significantly larger than the former if the implants replaced other contraceptive methods. These results would suggest that this substitution effect was negligible and that the devices themselves played a relevant role. This should not be totally surprising if we bear in mind that almost half of teenagers who gave birth a year before the program began became pregnant again in the next 4 years. Another possible explanation has to do with the existence of measurement error in the register of implants (which we have to manually match to birth registers).

Last, it is possible that mothers' contact with the qualified and committed health professionals overseeing the program might have resulted in an increased use of other contraceptive methods in their next pregnancy since these medical staff offered counseling on other contraceptive measures as well. This could particularly be the case among mothers who had certain medical conditions (diabetes, hypertension, or major depression, among others), who were on certain medications that doctors recommend not to combine with implant devices, or who did not like the devices' side effects.[4] The support from previous literature for these kinds of approaches (as highlighted in Section 2) and the fact that the program's design and implementation hinged on quite high motivation levels among medical staff underscore the plausibility of this mechanism. Unfortunately, we do not have actual information on this matter (similarly to how we do not know who received an implant offer). However, although we cannot disentangle the role of the different potential channels, note that this staff contact element is an intrinsic ingredient of this specific program.

To study the impact of the program across different types of mothers, we stratify the sample on several relevant dimensions measured at the time of birth. Table 4 displays the impact of the program by mothers' education, marital status, parity and gestation length. The main findings of this analysis reveal that the effect is negative and statistically different from zero for mothers with low educational attainment, those with a partner at the time of birth, those who had already had children and those who had a premature birth. Although our results suggest that the program is particularly effective in curbing fertility among mothers from disadvantaged social backgrounds, one should interpret them with caution because of the relatively low statistical power (i,e., the low number of observations in certain categories) when we split the total sample. Indeed, using seemingly unrelated regressions, we cannot reject the hypothesis of homogeneous effects across the categories of each of the four stratification variables.

Table 5 presents the analysis of the selection effects. We look at whether the characteristics of subsequent births in the next 48 months after the mother's receipt of the implant differ from those of subsequent births to mothers above the age threshold when they gave birth. The only variable on which we detect a statistically significant effect is the share of single mothers. This outcome shows a 14-percentage-point decline. The impact is not significantly different from zero in the rest of variables that we examine, and therefore, the reduction in fertility induced by the program will have corresponded to positive selection in subsequent births, as well. Nevertheless, one should bear in mind that the sample available for this exercise shrinks dramatically because barely a quarter of women gave birth to another child during the 48-month window.

Table 6 shows our robustness checks. In our baseline specification, we favor a quadratic in age since the specialized literature discourages the use of higher-degree polynomials because of their large sensitivity to the order of the polynomial and poor coverage of confidence intervals Gelman and Imbens (2019).[5] In columns (I) and (II), we assess whether our main results vary when we make use of local linear and polynomial regressions with optimal bandwidth selection (Calonico et al., 2019). The results remain qualitatively and quantitatively the same. The second sensitivity analysis involves modifying the bandwidth. Neither narrowing (column [III]) nor widening the window (column [IV]) around the cut-off alters the estimated impact of the program in a relevant way.

Our final robustness assessment comprises two placebo tests (columns [V] and [VI]). The first one focuses on a similar time window but 1 year earlier (i.e., we look at the effect among mothers who gave birth when they were less than 20 years old at CHPR between November 1, 2013 and December 31, 2014). The second test focuses on mothers who gave birth at private hospitals—where subdermal implants were not available—during the period when the program operated at CHPR. Reassuringly, neither of the estimated coefficients for the associated placebo policies is significantly different from zero.

We conclude this section by commenting on possible external validity concerns. First, using an RDD implies that we can estimate a local ITT effect. Nevertheless, the relevance of the group affected by the discontinuity (teenagers) ensures the pertinence of the analysis. A second potential issue is that the program seeks to prevent repeat teenage pregnancy. This is not a rare phenomenon—as mentioned above, before the program began, approximately one-third of the mothers around the discontinuity threshold had another child in the following 4 years—but it certainly does not represent the whole universe of adolescent births. Nevertheless, even if these mothers already have children, repeat teenage pregnancy is still a quantitatively important issue that has been specifically explored in previous research elsewhere (Luca et al., 2021).

Moreover, there may be specific barriers to realizing the potential benefits of subdermal implants for other groups (nulliparous women). For instance, adolescents from disadvantaged social backgrounds rarely use preventive services where doctors could offer the method, and they might not be easy to reach using informational campaigns. However, authorities might consider monetary incentives (Heil et al., 2012) given the high burden from unintended births, which are very common among teenage mothers (Bearak et al., 2022), and doctors could advise them to attend preventive check-ups where they would be offered the implant.

Third, our findings concern a single hospital center; nevertheless, CHPR is the largest maternity hospital in the country and mostly attends to the population groups in which teenage pregnancy is most prevalent. Specifically, this center concentrates

TABLE 4 Heterogeneity in the effects of the program.

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
	Education		Marital status		Parity		Gestation length	
	Primary or less	Lower sec-ondary and above	Single	With partner	First birth	Higher-order birth	Pre-term birth	Full-term birth
Intention to treat (age <20)	−0.144**	0.006	−0.108	−0.103*	−0.050	−0.197**	−0.256*	−0.083
	(0.062)	(0.082)	(0.089)	(0.059)	(0.060)	(0.081)	(0.130)	(0.051)
Quadratic form	✓	✓	✓	✓	✓	✓	✓	✓
Interaction	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Month fixed effects	✓	✓	✓	✓	✓	✓	✓	✓
No. of observations	1771	786	874	1730	1729	1026	294	2461
Mean of dependent variable	0.286	0.207	0.270	0.255	0.256	0.276	0.259	0.264

Note: The estimated coefficients reflect the change in the probability of having another child 48 months after the birth when the mother could have received the implant offer. Robust standard errors are in parentheses. The model includes only mothers who gave birth between 30 months before and 30 months after their 20th birthday. All the variables refer to the time of the birth when the mother could have received the implant offer.

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source: Authors' analysis from SIP.

TABLE 5 Selection effects: Program's impact on the characteristics of subsequent births.

	(I)	(II)	(III)	(IV)	(V)	(VI)
	Lower secondary and above	Single mother	Pre-term birth	Apgar score at 1 min.	Birth weight	No. of prenatal controls
Intention to treat (age <20)	−0.010	−0.143*	−0.032	0.090	−56.198	−0.232
	(0.077)	(0.086)	(0.065)	(0.275)	(116.843)	(0.629)
Quadratic form	✓	✓	✓	✓	✓	✓
Interaction	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓
Month fixed effects	✓	✓	✓	✓	✓	✓
No. of observations	842	842	842	842	842	842
Mean of dependent variable	0.195	0.195	0.106	8.494	3239	7.545

Note: Robust standard errors are in parentheses. The model includes only mothers who gave birth between 30 months before and 30 months after their 20th birthday. All the variables refer to the time of the first birth, in the next 48 months, after the one when the mother could have received the implant offer.

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source: Authors' analysis from SIP.

24% of total teenage births and 40% of those births at public hospitals in the country (50% and 77% in Montevideo, the capital city, respectively).

Fourth, the impact of the intervention in places where repeat adolescent motherhood is less frequent than in Uruguay should be smaller. Conversely, in countries where contraception is not as widespread or pregnancy termination or the morning-after pill are not available, the impact of this type of intervention could be even larger. In this respect, we would expect that the transferability of the policy to other Latin American and Caribbean countries (where access to contraception and abortion is overall much lower than in Uruguay) is potentially high.

Finally, it is difficult to conjecture what the impact of this intervention would be if it were implemented in the private sector. On the one hand, it is possible that adolescent mothers from upper middle- and upper-class socioeconomic backgrounds (the main users of private health care) would be more likely to accept the implant. Furthermore, this population segment, on average, exhibits a lower fertility rate. On the other hand, the fact that it is quite likely that teenagers from better-off families who decide to carry a pregnancy to term are strongly selected (in that they not only avoided the use of contraception but also ruled out

TABLE 6 Robustness checks.

	(I) Local linear regression	(II) Local quadratic regression	(III) 48-month interval	(IV) 72-month interval	(V) Placebo 1: Previous year	(VI) Placebo 2: Private hospitals
Intention to treat (age <20)	−0.091**	−0.113**	−0.119**	−0.086*	−0.013	−0.038
	(0.048)	(0.048)	(0.053)	(0.044)	(0.051)	(0.040)
Quadratic form			✓	✓	✓	✓
Local linear form	✓					
Local quadratic form		✓				
Controls	✓	✓	✓	✓	✓	✓
Interaction	✓	✓	✓	✓	✓	✓
Month fixed effects	✓	✓	✓	✓	✓	✓
No. of observations	7211	2981	2365	3102	3027	4330
Mean of dependent variable	0.214	0.214	0.261	0.258	0.362	0.255

Note: The estimated coefficients reflect the change in the probability of having another child 48 months after the birth when the mother could have received the implant offer or the timing of the placebo intervention. Robust standard errors are in parentheses. The number of observations effectively used in the estimators for columns (I) and (II) are 1712 and 2,981, respectively.

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source: Authors' analysis from SIP.

abortion), so they could be more reluctant to adopt birth control methods of any kind (e.g., because of strong religious motivations). Therefore, the likely impact of implementing this program in the private sector is quite unclear.

5 | CONCLUSION

Teenage motherhood is a societal challenge due to the costs that it imposes on both parents and children, and it affects both low- and high-income regions. This work analyses the impact of a subdermal contraceptive program on repeat teenage motherhood in Uruguay. Using an RDD, we find that mothers experienced a 10% reduction in their probability of having another child in next 48 months after the implant offer. This figure is extremely close to the findings of the randomized trial of Luca et al. (2021) in both qualitative and quantitative terms.

Our results suggest that the program is cost-effective. We do not know the exact amount of resources invested in the intervention, but the approximate figures provided in Subsection 3.1 indicate that the overall cost is around US$ 18 per unit. This figure is dwarfed by the high burden of unintended pregnancies. Although no figures for Uruguay are available, based on the cost of a live birth in Chile and some assumptions drawn from studies for the United States, we estimate the cost of an unintended pregnancy that includes prenatal and postnatal care until 60 months after delivery to amount to US$ 2707.[6]

Our study has several limitations. First, we cannot totally disentangle the impact of the subdermal implants from the other possible mechanisms through which the program could have affected fertility, such as better information on other contraceptive methods. Nevertheless, when we compare the estimated change in fertility to the estimated rate of implant adoption, we cannot rule out that the effects of the program could be partly attributable to the latter. Second, our research does not address the impact on sexually transmitted diseases. It is possible that part of the adopters switched to implants from barrier contraceptive methods, which could lead to a rise in these types of infections.

Third, further research should address the medium- and long-run impact of the program on outcomes such as educational attainment or positive spillovers on other younger children in the family due to the reduction in fertility. Fourth, the benefits of the program identified by this paper do not cover the likely increased well-being associated with subdermal implants relative to that associated with other methods. Last, it is still unclear whether this method the most cost-effective contraception measure, particularly relative to intrauterine devices (Farah et al., 2022; Guerra et al., 2015; Henry et al., 2014; Mavranezouli, 2008; Ngacha & Ayah, 2022; Trussell et al., 2013). This judgment critically depends on adherence rates, which could well be country specific.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The main data source of this paper is the Perinatal Information System, which are available from the Ministry of Public Health of Uruguay and were used under license for this study. The work also makes use of information on implant recipients obtained from the Hospital Pereira Rossell. The latter are available from the authors with the permission of the hospital. The code for replicating the results is available from J.-I. Antón upon request.

ORCID

Zuleika Ferre https://orcid.org/0000-0002-2795-5873
Patricia Triunfo https://orcid.org/0000-0001-6342-3295
José-Ignacio Antón https://orcid.org/0000-0001-9623-3121

ENDNOTES

1 If we knew to whom CHPR offered an implant, we could estimate the local average treatment effect using a fuzzy RDD where the age cut-off serves as an instrumental variable for being offered an implant. Unfortunately, this information is not available.

2 Figure A1 in the appendix illustrates the effect of the discontinuity graphically. The *p*-value of the difference is below 0.05.

3 The *p*-value of the difference at the cut-off is below 0.05. Note that, contrary to conventional wisdom, a statistically significant result at a certain level of difference does not require us to compute nonoverlapping confidence intervals at the same threshold (Julious, 2004; MacGregor-Fors & Payton, 2013).

4 For an example, see the guidelines of the British National Health System (2021) or the Mayo Clinic (2021).

5 In any case, the use of a cubic and a quartic function also indicates a negative effect on fertility, specifically, a reduction of 14.2 and 21.1 percentage points, respectively.

6 Also located in the Southern Cone, Chile exhibits a level of economic development, medical technology and quality of public health care similar to Uruguay's. The public health care system in Chile resorts to modern forms of management such as quasi-market arrangements and subcontracting. This results in much better availability of information on medical costs in Chile than in Uruguay. Specifically, the cost of a delivery, including hospitalization, in Chile in 2016 was US$ 1510 (Fondo Nacional de Salud, 2023). Our estimation relies on the following assumptions. First, the cost of a live birth in Chile is 3.5 times lower than that in the United States (Trussell et al., 2013). We assume that this proportion holds for the total cost including prenatal and postnatal care. Second, the share of the total costs (comprising delivery and prenatal and postnatal care) in Chile is the same as in the United States (taken from Sonfield and Kost (2015)). Third, we adjust for mistimed pregnancy (many unintended births often just come earlier than desired) using the same factor as (Trussell et al., 2013) for females aged 18–19 years old in the United States. Note that the final figure probably seriously underestimates the total cost of unintended pregnancy because it excludes private and external costs due to the impact of teenage birth on mothers and children's socioeconomic outcomes (e.g., those associated with the negative impact on mothers' educational attainment).

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APPENDIX A

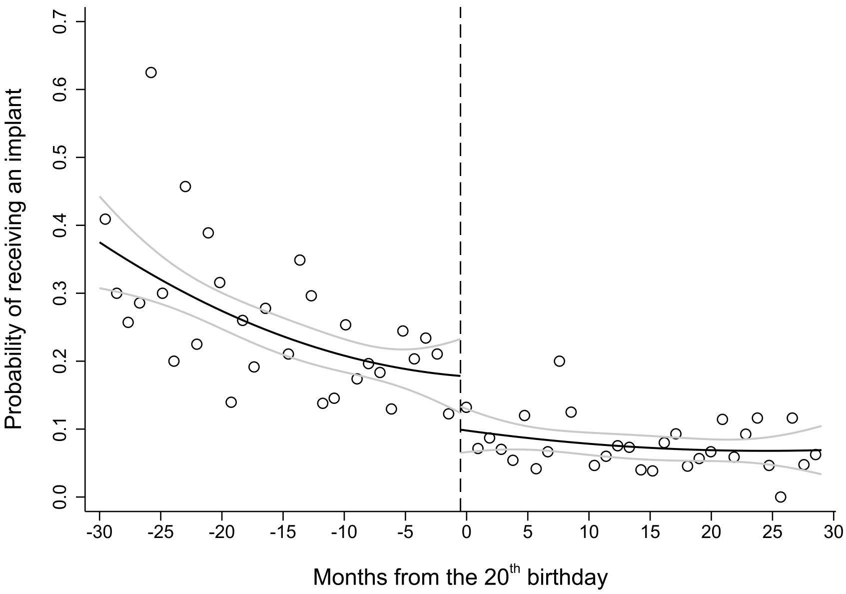

FIGURE A1 Effect on women's probability of receiving an implant after giving birth by months from 20th birthday. The figure shows women's probability of receiving an implant after giving birth from November 1, 2015 to December 31, 2016. We estimate a quadratic separately at both sides of the cut-off. Gray lines are point-wise 90% confidence intervals. *Source*: Authors' analysis from SIP.

TABLE A1 Descriptive statistics.

	Mean	Standard deviation
Implant after birth	0.157	0.364
Another child in the next 48 months	0.263	0.440
Age	20.066	1.315
Single	0.317	0.465
Missing marital status	0.055	0.228
Lower secondary or above	0.285	0.452
Missing education	0.072	0.258
Previous births	0.372	0.484
Pre-term birth	0.107	0.309
Apgar score at 1 min	8.366	1.430
Birth weight (g)	3180.248	602.969
No. of prenatal controls	7.886	3.256
No. of observations	2755	

Source: Authors' analysis from SIP.