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Human papillomavirus vaccine and risky sexual behavior: Regression discontinuity design evidence from Brazil

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ABSTRACT

This study aims to analyze the hypothesis of moral hazard caused by vaccination against human papillomavirus (HPV), regarding girls' beginning of sex life and, once they have begun their sex life, to understand whether it reduces the probability of girls using a condom in their first sexual intercourse. The data are from the 2015 National Survey of School Health (PeNSE). The model used is the regression discontinuity, with the discontinuity in the age of the girls who were able to participate in the public vaccination campaign. The results of the so-called Fuzzy-RDD show that the campaign was effective in increasing the likelihood of vaccination by 26.7–27.6 percentage points. There is no observable effect on young women initiating their sex lives or refraining from using condoms. The results are tested by several robustness methods. This is the first work to use quasi-experimental models in a developing country with low vaccination coverage in Latin America and show that it is necessary to increase awareness campaigns with parents, so they will know that there is no effect of vaccination on the beginning of sex life and condom use.

1. Introduction

The HPV (Human Papillomavirus) is the main causative agent for the incidence of cervical cancer among women. It is highly contagious, and contamination can occur after a single exposure. Its transmission occurs by direct contact with the affected skin or mucosa, and sex is its main form of contagion. In addition, it can also be transmitted from mother to child during childbirth. HPV can cause abnormal growth of the baby's cells, which can lead to death (Diaz et al., 2008).

The risk of infection increases with risk behavior and number of sexual partners. The duration of infection is contingent on the HPV type. The vast majority of infections are benign, usually going away on their own. The estimate is that between 3 and 10 % of women in different populations can not kill off the infection and become persistent carriers of HPV, becoming the high-risk group for progression to cervical cancer (Monsonego et al., 2004)

The prevalence of HPV infection is twice as high in Latin America compared to the rest of the world and is associated with 68,220 new cases of cervical cancer per year. Incidence rates range from 20 to 80 women per 100,000 and across the continent, 31,712 deaths from cervical cancer are reported annually (Nogueira-Rodrigues et al., 2017). According to the National Cancer Institute (INCA, 2018) this type of cancer is the second most frequent tumor in the female population and the fourth cause of death from cancer of women in Brazil. The estimate for 2018 is 16,370 new cases in the country, with approximately 5000 annual deaths.

Vaccination against Human Papillomavirus appears as an alternative to prevent infection – the vaccine has been available on the public health system in Brazil since March 2014 for girls and since 2017 for boys. The public campaign for HPV immunization in Brazil began in 2014 for girls aged 11–14 years old – indigenous girls from 9 years old onwards[1] – reducing the vaccination age for girls from 9 years old to 10 years old in 2016. The definition of age between 9 and 13 years old was chosen because studies indicate that the vaccine is more effective in this age group, preferably before the beginning of sexual life - i.e. before exposure to the virus (Ministério da Saúde, 2014). The vaccine in 2014 was designed in a three-dose scheme: the first in March 2014 in Basic Health Units (UBS) and in schools, the second and third doses, respectively, would be given 6 and 60 months after the first dose. Both doses are

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[1] Indigenous women's behavioral patterns, such as beginning their sex lives early and having multiple partners, increase the likelihood of HPV infection (Rodrigues et al., 2014). The rate of cervical cancer morbidity and mortality in this population is twice as high when compared to non-indigenous women (Speck et al., 2015).

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administered in the UBS, this extended system made it possible to vaccinate more girls without overwhelming vaccination teams or interfering with other vaccines (Ministério da Saúde, 2014).

The Ministry of Health's goal is 80 % vaccination coverage, so that transmission would be reduced even among non-vaccinated people. With enhanced collective immunity, it is possible to stop the mechanism of sexual transmission and to eradicate the high-risk HPV (Tertuliano et al., 2018). As of 2016, the vaccination campaign emphasizes that the vaccine is administered in two doses – as studies have shown the same efficacy of the vaccine in two or three doses – making it possible for boys to be included in the campaign in 2017 (Santos and Dias, 2018).

The Brazilian Health System has extensive experience in vaccination coverage, with the promotion of national vaccination policies (Zardo et al., 2014). The campaign against HPV, however, did not work as expected and only 64.77 % of the girls received the second dose of the vaccine, and the northern region stands out, with only 43.6 % of the girls receiving the second dose – no region has reached the goal of 80 % vaccination (DATASUS, 2015).

However, its reach is still limited. Most individuals tend to maintain the status quo, that is, while the vaccine is new and optional, and although there is scientific evidence of its effectiveness, parents tend not to take their children to receive the vaccine, mainly because it consists of two or more doses. Although the child may receive the first dose, they do not end the vaccination cycle without the additional dose, according to a study for the USA (Caskey et al., 2017). The vaccine is shown to be highly effective for approximately 70 % of HPV types (Skinner et al., 2008). However, there is much controversy surrounding HPV vaccination because it can cause ex-ante moral hazard problems (Dave and Kaestner, 2009; Ehrlich and Becker, 1972), since vaccinated girls could feel encouraged to engage in risk behavior due to the immunization generated by the vaccine, as such controversy is based on fears that the vaccine increases the risk of adopting risky sexual behaviors and undermines parental authority (Roitman, 2015). Because the vaccine is prophylactic and its major public health benefit comes from the prevention of infections, the population that must be vaccinated is that of preadolescents, so parental consent is essential. They may be concerned that their teenage children interpret parental approval of the vaccine as a tacit consent to early sexual behavior. Preadolescents and adolescents are more likely to have questions about sexual health care than children, and parents may be wary of describing the HPV vaccine to their daughters (Vamos et al., 2008; Zimet, 2005).

Studies for the US and the UK show that part of the problem is the parental belief that vaccination would be a positive nod to risky sexual behaviors (Ferrer et al., 2016), such as early sex, not using condoms and having multiple sexual partners. Parental belief, however, has no basis in the literature, which refutes this hypothesis (Davis et al., 2004; Mullins et al., 2012, 2016). Risky sexual behaviors are not correlated with the HPV vaccine, they are therefore directly associated with misconceptions about Sexually Transmitted Infections (STIs) (Mayhew et al., 2014).

This study aims to evaluate whether vaccination against HPV affects the beginning of sex life of girls whose age is close to the cut-off point of the public vaccination campaign. In addition, the study aims to assess whether girls who have already initiated their sex life have stopped protecting themselves with condoms because of the vaccine. The beneficiaries of the campaign were girls as young as 14 in March 2014 and who could receive the vaccine for free. However, those aged 14 years or older could receive it only in private clinics. The data are from the 2015 National Survey of School Health (PeNSE). The methodology used was Regression Discontinuity. Although there is a vast international literature on the subject (Moghtaderi and Dor, 2019; Smith et al., 2015), this type of evaluation is still new for Brazil as a whole.

This work advances in making the first quasi-experimental study on early sexual life and absence of condom use in the first sexual intercourse. It should be added that it is the first quasi-experimental study on HPV vaccination in a developing country, especially a Latin American country where the vaccination campaign was below target. As mentioned above, the prevalence of HPV infection in Latin America is twice as high as in the rest of the world. Thus, strong arguments can be made against the claim that the vaccine prompts risky sexual behavior, stimulating increased coverage against viruses and reducing costs associated with diseases, especially cervical cancer.

In addition to this introduction, there is a section explaining the HPV vaccination campaign, as well as the literature on the vaccine's influence on indicators of sexual behavior. The third section describes the model used. The fourth section provides a descriptive analysis of the data, as well as a brief explanation of the PeNSE database, which contains socioeconomic, health and other information for Brazilian students. The fifth section is about results and robustness. Lastly, the final considerations are made.

2. Background

Fakes news can play a negative role in the vaccination campaign. In Denmark, the media played an important role in the search for vaccines to prevent HPV, and a drop in demand was identified after news of serious side effects of the vaccine came out. An even steeper decline was noted shortly after a TV documentary criticized the vaccine (Hansen and Schmidtblaicher, 2019). However, HPV awareness has the power to increase the rate of completion of the HPV vaccination cycle. In addition, school health centers are important sources of appropriate education for young people and their parents (Bellia-Weiss et al., 2012).

Chinese girls from 4 high schools in Hong Kong participated in an education program on HPV and cervical cancer. The results show that girls who participated in the program have an 11.3 % increase in the intention to receive the HPV vaccine. Among the girls whose parents or colleagues did not approve of the vaccine before the program, approximately 40 % started to perceive their support afterwards (Kwan et al., 2011). Korean youths, both boys and girls, who know that the vaccine prevents cervical cancer are significantly associated with the intention to receive the vaccine (Kim, 2015).

Although the parents' bias is a relevant factor, some characteristics of the mother are important for the girl to receive the vaccine: mothers with high school education or less, who supervise their daughters when they go out with colleagues and who have a history of STI, are more likely to vaccinate their daughters (Rosenthal et al., 2008).

More recently, some quasi-experimental studies for the USA, Denmark and Canada have tested the hypothesis of an association between vaccination against Human Papillomavirus and risky sexual behaviors, in order to have some degree of causality to make an inference possible. The results show that there is no relationship between immunization by means of the vaccine and risky sexual behaviors (Smith et al., 2015). Vaccinated women continue to do a Pap test (Moghtaderi and Dor, 2019), and when comparing children of vaccinated and unvaccinated women, there is no evidence of differences between groups with regard to low weight or short stature, premature birth and congenital malformation. There are also no effects of the vaccine on miscarriage (Scheller et al., 2017).

3. Materials and methods

The Regression Discontinuity Design (RDD) is a quasi-experimental method that attempts to approach an experiment at a given location. The hypothesis is that, given a discontinuity (affecting the

Table 1
Descriptive statistics and description of variables.

Variable	Description	Beginning of sex life			Wore a condom		
		Control Mean(SD)	Treatment Mean(SD)	t	Control Mean(SD)	Treatment Mean(SD)	t
Job	1 = has a job, 0 i/o	0.10 (0.31)	0.07 (0.26)	**	0,16 (0,36)	0,16 (0,37)	
Full-time	1 = studies full-time, 0 i/o	0.23 (0.42)	0.21 (0.40)	**	0,24 (0,42)	0,26 (0,44)	
Health Status [a]	Reported health	0.62 (0.48)	0.69 (0.46)	**	0,56 (0,5)	0,62 (0,48)	**
SEL [b]	Socioeconomic level	−0.19 (1)	0.07 (0.99)	**	−0,35 (0,97)	−0,18 (1)	**
Had sex	1 = has begun sex life, 0 i/o	0.25 (0.43)	0.08 (0.28)	**			
Wore a condom	1 = wore a condom in the first intercourse, 0 i/o				0,73 (0,45)	0,74 (0,44)	
Vaccinated	1 = received the HPV vaccine, 0 i/o	0.73 (0.44)			0.48 (0.5)		
	Observations	9,322	26,098		2,348	2,164	

Source: Prepared by the author. $^{**}p < 0.01$ and $^{*}p < 0.05$.
Note: [a] It assumes 1 when health is good or very good and 0 when health is regular, bad or very bad. [b] Estimated via factor analysis with the extraction of the main components. Items related to the girl's home that were included in the factor analysis for the estimation of SEL: the presence of a computer, car, motorcycle, cell phone, internet, landline, housemaid and bathroom at home. i/o: if otherwise. SD: Standard deviation. t: *t*-test. The continuity test for these and other covariates in this table are in Fig. A1 of the Appendix.

probability of the treatment), girls around this cutoff are very similar in characteristics but because of exogenous reason they have higher or smaller chances of being treated (Lee and Lemieux, 2010).

Since it is a Fuzzy case, where the cutoff changes the probability of treatment, but it is not deterministic, the variable that affects the treatment (Z_i) increases the chances of the girl receiving the vaccine. In other words, being born as of March 2000 increases the chances of the girl being vaccinated, but they may not be vaccinated by parental determination. Girls born before December of the previous year have a lower chance of receiving the vaccine, however, they can seek it by private means.

Some assumptions are necessary to estimate the Fuzzy RDD. The first assumption (of identification) is ignorability: girls can not manipulate the variable to be treated or not. This assumption will be tested with the method developed by Cattaneo, Jansson and Ma (2019) – which tests whether the running variable is continuous around the discontinuity. Tests carried out to determine whether the running variable has been manipulated are called falsification tests (Cattaneo et al., 2018; Cattaneo and Vazquez-Bare, 2016).

The second assumption is called continuity: all unobservable factors are continuously distributed in relation to X. This assumption guarantees the causal effect of the treatment. By means of a graphical analysis, it will be shown that some of the main observable covariates are also continuous around the discontinuity.

The third assumption refers to the monotonicity: this guarantees the elimination of the so-called defiers, in other words, girls who are no longer treated because they are part of the treatment group – girls who are old enough to receive the vaccine but who did not receive it are called never-takers. The fourth assumption assures that the running variable can only affect the outcome variable through treatment. Otherwise, the age, in months, can only affect the decision of the girls to initiate sexual life or not to use a condom through the vaccine.

Given the previous assumptions, the estimation of the treatment effect on the treated (ATT) of the Fuzzy method is given by the following equation:

$$ATT^f = \frac{\lim_{x \to e^+} E[Y_i Z_i = c + e] - \lim_{x \to e^-} E[Y_i Z_i = c - e]}{\lim_{x \to e^+} E[T_i Z_i = c + e] - \lim_{x \to e^-} E[T_i Z_i = c - e]} \quad (1)$$

Where: Y is the outcome variable (having sex or using a condom in the first intercourse), C is the cutoff (being 14 years old in March 2014) and Z is the age in months.

The Fuzzy RDD estimator can be summarized by means of Eq. (2):

$$\hat{\tau}^f = \frac{Y^+ - Y^-}{T^+ - T^-} \quad (2)$$

That is, the estimator is given by the ratio of the difference of the result to girls who are above the cutoff with the result of the girls who are below it to the difference of the treatment of the girls who approach the cutoff on top minus the treatment of the girls who approach it under.

4. Data

This study uses data from the National Survey of School Health (PeNSE) collected by the Brazilian Institute of Geography and Statistics (IBGE). PeNSE is based on a representative sample at the national level, Major Regions, Federation Units and Capital Municipalities of Brazilian young people who are attending the 9th year of elementary education in public or private schools[2] . More specifically, PeNSE provides information on socioeconomic aspects; family context; eating habits; physical activity practice; experimentation and consumption of cigarettes, alcohol and other drugs; sexual and reproductive health; use of health services; among other aspects. For the purposes of this study, the most recent research data (PeNSE 2015) are used.

This work explores the variation of date of birth, in months, along with the period of initiation of the HPV vaccination campaign as an exogenous source to estimate i) the effect on the probability of initiating sexual life after vaccination and ii) the effect on the probability of not using a condom in the first sexual intercourse, in case the subject has started her sex life. For this purpose, PeNSE provides information on the year and month of birth of the interviewee. Thus, it is possible to determine the

[2] There are, however, students between the sixth grade and the third year of high school, but the total number of students who are not in the ninth year is about 1.5% of the total sample.

individual's age in months, which was calculated for December 2013. Therefore, those who had up to 165 months of life (or 13 years and 11 months in March 2014) are part of the treatment group. Table 1 presents the main variables used in the study. Girls who began their sex life at an age below the age at which they would receive the vaccination were removed from the sample.

The variables analyzed are beginning of sex life and use of condoms in the first sexual intercourse. The number of observations for each variable is different because the first dependent variable (35420 observations) considers all girls in the sample - the girl answered the question "Have you ever had sex (had sex)?". In the second dependent variable, only girls who answered "yes" in the first question were considered (4512 observations) - the question was "Did you wear a condom in the first sexual intercourse?". The school is not identified in the sample and information about the students are confidential (IBGE, 2016).

From the group of girls in the "beginning of sex life" column, the control group has a higher percentage of girls working and a higher percentage of girls working full-time. The treatment group has a higher percentage of girls whose self-reported health is good or very good and who have a higher socioeconomic level. In the control group, 25 % of the girls began their sex life, while in the treatment group, 8% of them did. In the "wore a condom" column, most covariates are not statistically different, with 73 % of the girls in the control group having worn condoms in the first sexual intercourse and 74 % in the second. In both groups, 16 % of the girls are employed. The treatment group has 26 % of girls studying full-time, while the control group has 24 %. The treatment group has

Table A1
Descriptive statistics of variables used in the robustness.

Variable	Description	Beginning of sex life			Wore a condom		
		Control Mean(SD)	Treatment Mean(SD)	T	Control Mean(SD)	Treatment Mean(SD)	T
Capital	1 = state's capital, 0 i/o	0.52 (0.5)	0.51 (0.5)		0.52 (0.5)	0.46 (0.5)	**
Age-Grade Distortion	1 = school lag of 2 years or more, 0 i/o	0.25 (0.43)	0.03 (0.16)	**	0.45 (0.5)	0.15 (0.36)	**
No. of people in the household	Total people in the household	4.61 (1.67)	4.43 (1.5)	**	4.63 (1.81)	4.54 (1.76)	
Lives with the mother	1 = lives with the mother, 0 i/o	0.88 (0.32)	0.92 (0.27)	**	0.81 (0.39)	0.85 (0.36)	**
Lives with the father	1 = lives with the father, 0 i/o	0.56 (0.5)	0.63 (0.48)	**	0.45 (0.5)	0.49 (0.5)	**
Mother's Education2	1 = mother did not finish elementary school, 0 i/o	0.3 (0.46)	0.23 (0.42)	**	0.37 (0.48)	0.29 (0.45)	**
Mother's Education3	1 = mother finished elementary school, 0 i/o	0.08 (0.27)	0.07 (0.26)	*	0.08 (0.27)	0.09 (0.09)	
Mother's Education4	1 = mother did not finish high school, 0 i/o	0.09 (0.28)	0.08 (0.28)		0.09 (0.29)	0.09 (0.29)	
Mother's Education5	1 = mother finished high school, 0 i/o	0.21 (0.41)	0.24 (0.43)	**	0.19 (0.39)	0.21 (0.41)	
Mother's Education6	1 = mother did not finish higher education, 0 i/o	0.06 (0.24)	0.07 (0.26)	**	0.04 (0.21)	0.08 (0.26)	
Mother's Education7	1 = mother finished higher education, 0 i/o	0.15 (0.36)	0.25 (0.43)	**	0.09 (0.29)	0.14 (0.35)	**
Has smoked	1 = has smoked tobacco, 0 i/o	0.21 (0.41)	0.12 (0.32)	**	0.42 (0.49)	0.37 (0.48)	**
Has drank	1 = has drank alcohol, 0 i/o	0.58 (0.49)	0.48 (0.5)	**	0.82 (0.38)	0.81 (0.39)	
Has used drugs	1 = has used illicit drugs, 0 i/o	0.09 (0.29)	0.05 (0.21)		0.22 (0.41)	0.21 (0.41)	
Self-declared Black	1 = self-declared black, 0 i/o	0.12 (0.32)	0.09 (0.28)	**	0.13 (0.33)	0.11 (0.31)	*
Self-declared Asian	1 = self-declared Asian, 0 i/o	0.06 (0.23)	0.05 (0.22)		0.05 (0.23)	0.05 (0.21)	
Self-declared Mixed-Race	1 = self-declared mixed-race, 0 i/o	0.47 (0.5)	0.48 (0.5)		0.51 (0.5)	0.50 (0.5)	
Self-declared Indigenous	1 = self-declared indigenous, 0 i/o	0.04 (0.18)	0.03 (0.18)	*	0.04 (0.19)	0.04 (0.2)	
Skipped school without permission	No. of days that they skipped school without the parents' permission in the last month[a]	1.35 (0.76)	1.21 (1.2)	**	1.57 (0.94)	1.51 (0.89)	*
Parents knew what they were doing	No. of days that the parents knew what the student was doing[b]	3.84 (1.32)	4.00 (1.21)	**	3.59 (1.38)	3.56 (1.39)	
Parents check the homework	How often the parents checked the homework[b]	2.65 (1.47)	2.73 (1.46)	**	2.54 (1.49)	2.64 (1.52)	*
Parents understand problems	How often the parents understood their problems and concerns[b]	3.02 (1.47)	3.16 (1.44)	**	2.86 (1.5)	2.98 (1.51)	**
Urban	1 = urban area, 0 i/o	0.92 (0.27)	0.93 (0.25)	*	0.92 (0.28)	0.9 (0.29)	
Private school	1 = private school, 0 i/o	0.17 (0.38)	0.28 (0.45)	**	0.07 (0.25)	0.12 (0.32)	**
Observations		9.322	26.098		2.348	2.164	

Source: Prepared by the authors. **p < 0.01 and *p < 0.05.
Note: [a]1 = 0 day, 2 = 1 or 2 days, 3 = 3–5 days, 4 = 6–9 days, 5 = 10 or more days. [b] 1 = never, 2 = rarely, 3 = sometimes, 4 = most of the time, 5 = always. i/o: if otherwise. SD: Standard deviation. T: T-test.

more girls who consider their health to be good or very good and girls with a higher socioeconomic status. The other variables used in the robust model are in Appendix A (Table A1), in addition to a binary variable for each Federative Unit, in order to control regional effects that may affect the outcome variables.

5. Results

Fig. 1 below refers to the likelihood that the girl will be vaccinated. It is possible to notice that there is a very evident discontinuity in the cutoff, that is, it shows that the public vaccination policy increases the probability that girls under 14 years of age will be vaccinated. To the left side – beginning of sex life – girls located just before the discontinuity are more than 65 % likely to receive the vaccine, while girls who are located right after the discontinuity are above 40 %. To right side, girls before the discontinuity are 60 % more likely to receive the vaccine, and after the discontinuity, below 40 %.

Fig. 2 shows that there is continuity in the result variables before and after the cutoff. The left side of Fig. 2 shows that both girls under 14 years old and girls over 14 are approximately 25 % more likely to have begun their sex life. The right side of Fig. 2 shows that girls who have already began their sex life have a 70 % chance of wearing a condom in the first sexual intercourse, regardless of whether the girl is in the treatment or in the control group. The fact that the curves before and after the cutoff are within the confidence intervals (shaded area in the graph) prevents the null hypothesis that the results are different between groups from being rejected.

The first stage in Table 2 shows that public vaccination is effective in increasing the likelihood of younger girls receiving the vaccine. This result is important, since studies show that in Brazil the vaccination campaign is below the target and often the girls do not finish the vaccine cycle (Fonsêca et al., 2017; França et al., 2017), and the same is true for Latin America (Nogueira-Rodrigues et al., 2017).

The campaign aimed at young women is an important source of public policy aimed at spreading knowledge about vaccination and the effects of HPV on the lives of young people, since most people are unaware of the campaign and some are aware of the disease, but through the media and doctors, and not because of schools (Osis et al., 2014; Pereira et al., 2016; Unger et al., 2015).

The first column shows that there is no significance between taking the vaccine and anticipating the onset of sexual life – the early first sexual intercourse is one of the factors that increase the risk of HPV infection in Brazil (Castro-Silva et al., 2012; Roteli-Martins et al., 2007). This result is important because people are aware of the age of the vaccine, but they believe that vaccination anticipates the first sexual intercourse of girls (Almeida et al., 2014; Davis et al., 2004).

In short, Table 2 shows that younger girls are between 26.74 percentage points and 27.08 percentage points more likely to receive the vaccine against human papillomavirus, a result indicated by the first stage in both estimates: beginning of sex life and condom use in the first sexual intercourse. The second stage, however, does not point out to statistical significance - there is no evidence that vaccinated girls start having sex earlier or that they do not wear condoms because they feel protected from HPV. Therefore, there are no moral hazard problems resulting from vaccination.

5.1. Robustness analysis

Robustness is an important source for confirmation of results, as it helps to ensure that the results have not been affected by other factors. The cutoff is dislocated in the columns C (159) and C (171) for 6 months before and 6 months after the discontinuity, since it has no significant effect on either of the two evidences of the efficiency of the vaccination campaign of girls who turned 14 in the month of March 2014. França et al. (2017) had shown that the adherence to the vaccination campaign was large in the first dose in some federative units and regions (mainly South and Southeast)

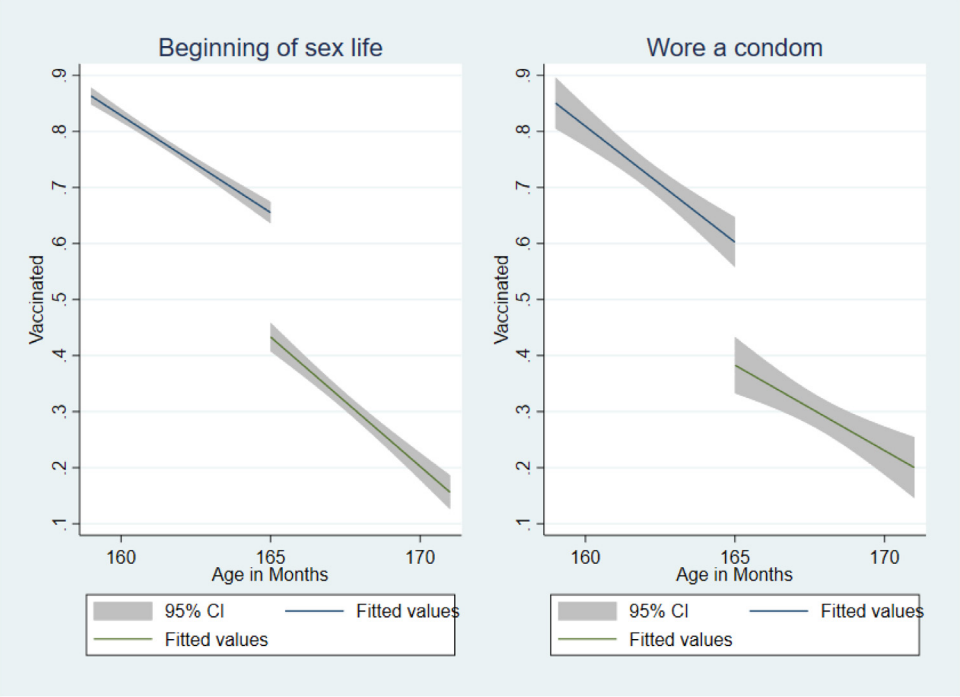

Fig. 1. Discontinuity in the probability of receiving the vaccine.

Source: Prepared by the author.

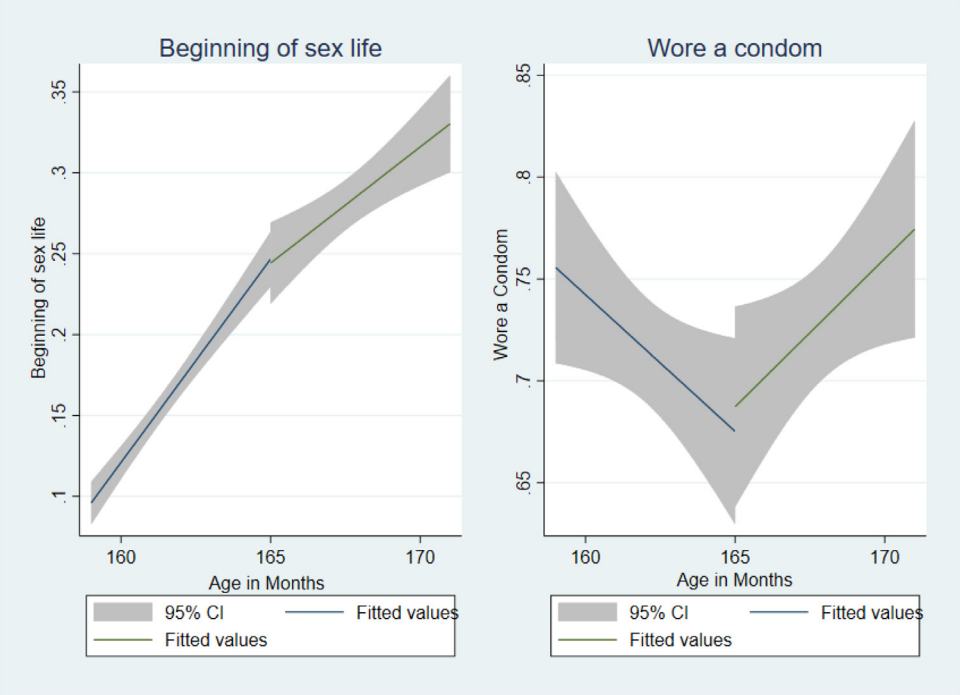

Fig. 2. Continuity in the probability of outcome variables.
Source: Prepared by the author.

Table 2
Effect of HPV vaccination on risky sexual behaviors.

	Beginning of sex life	Wore a condom
1st Stage	−0, 2674**	−0.2708**
	(0,022)	(0.05)
2nd Stage	0.0066	−0,1218
	(0.070)	(0.16)
H	6.259	6.259
B	11.300	11.300
ρ(H/B)	0.554	0.554

Source: Prepared by the author. **p < 0.01. Robust standard errors in parentheses. H is the main bandwidth; B is the bias bandwidth.
Note: Estimates for degree 1 polynomial without adding covariates.

Table 3
Robustness Analysis.

Beginning of sex life				
	P(1) Cov	P(2) Cov	C (159)	C (171)
1st Stage	−0.2319**(0.027)	−0.224**(0.026)	−0.0249	0.0358
			(0.025)	(0.034)
2nd Stage	0.1676	0.1214	0.5918	2.507
	(0.091)	(0.094)	(1.2604)	(7.035)
Wore a condom				
1st Stage	−0.202**	−0.2098**(0.060)	−0.0917	0.07
	(0.057)		(0.084)	(0.061)
2nd Stage	−0.2085	−0.3108(0.2727)	−0.052	0.801
	(0.245)		(1.786)	(2.069)
H	4.15	9.093	2.193	4.851
B	8.231	15.474	5.97	14.539
ρ(H/B)	0.504	0.588	0.367	0.333

Source: Prepared by the author. *p < 0.05, **p < 0.01. Robust standard errors in parentheses. H is the main bandwidth; B is the bias bandwidth.
Note: P(1) Cov and P(2) Cov refer to columns with covariates and degree 1 and degree 2 polynomials, respectively. Columns C (159) and C (171) are 6 months before the treatment cutoff and 6 months after the treatment cutoff, respectively.

and that the North region has a negative result, with only 38 % of the target reached.

Adding covariates and increasing the degree of the polynomial[3] are ways to demonstrate that the result is robust. The efficiency of the campaign depends on the location, therefore, dummies have been added for each federative unit. The state of Paraíba, for example, reached 56.55 % of the vaccination target in the second dose, while the national average was 55.57 % (Fonsêca et al., 2017).

Table 3, in columns P (1) Cov and P (2) Cov, shows that, even with the addition of covariates, there is no change in the results. Although the coefficient is smaller, younger girls are over 20 percentage points more likely of receiving HPV vaccination, when compared to those who had already turned 14 years old in the implementation of the vaccine. Similarly, Table 3 confirms that vaccinated girls do not behave statistically differently from unvaccinated girls.

There is an extensive literature on factors affecting the beginning of sex life and the decision whether to use condoms (such determinants are used as controls in robustness analysis, columns P(1) Cov and P(2) Cov), such as socioeconomic status – girls from wealthier families begin the sex life later (Lammers et al., 2000; Verona and Regnerus, 2014). Being employed is a factor that helps to anticipate the first sexual intercourse (Cruzeiro et al., 2008), as well as studying full-time (França and Frio, 2018).

Other important factors associated with the use of condoms and the age of the first sexual intercourse – also included as covariates in the robustness tests – refer to the use of licit drugs (tobacco and alcohol) and illicit drugs (Gambadauro et al., 2018; Madkour et al., 2010; Wilson et al., 2010) and the school, so that more educated young people are less likely to initiate sexual life early and to have unprotected sex (Cruzeiro et al., 2008; Okigbo and Speizer, 2015). In addition, the school contributes to the onset of sexual life when it teaches the students where to get a condom, or to delay such an onset, when it shows the girls the risks of an early pregnancy (França and Frio, 2018). The figures presented in

[3] From the degree 3, the software cannot calculate, because a problem of invertibility arises.

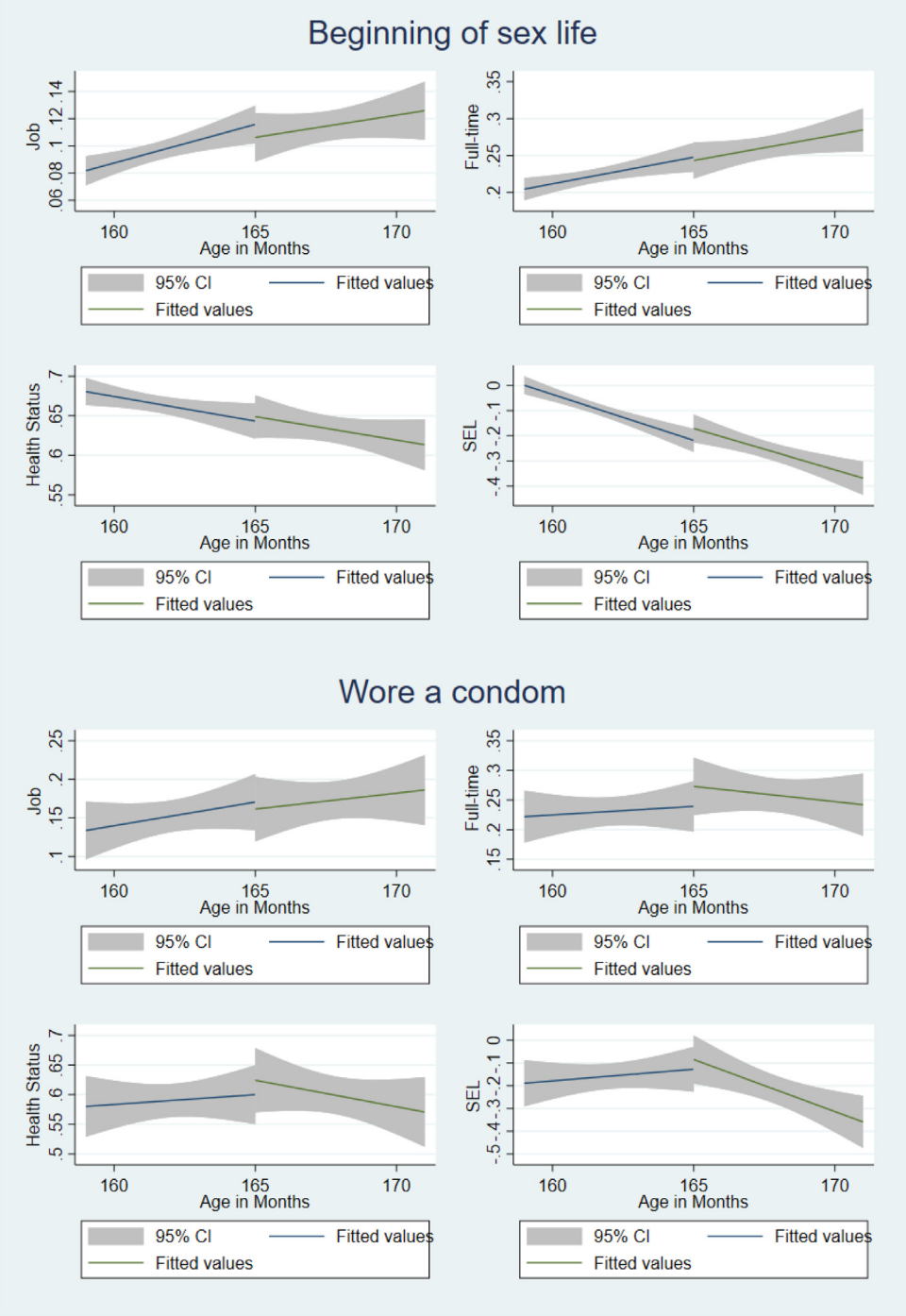

Fig. A1. Continuity in Some Covariates.

Appendix A1 show that the main covariates – presented in Table 1 – continue around the months of vaccination, showing that there are no other discontinuities affecting the treatment and the result through treatment.

Table 4
Manipulation test around the discontinuity.

Method	T Statistic	P-value
Beginning of sex life	−0.932	0.351
Wore a condom	−1.0994	0.272

Source: Prepared by the author.

Table 4 shows the manipulation test around the discontinuity (Cattaneo et al., 2019), where the null hypothesis is that there is continuity of the sample around the running variable. The values of the test statistic do not provide evidence to reject the null hypothesis. From the point of view of the vaccination program, the result is expected, since the vaccination is based on the age in 2014 and the discontinuity is in the months of life of girls who were born in the year 2000. There are no a priori forms of parental manipulation on the date of birth for their daughters to be treated (or not) 14 years later.

In addition to the test shown in Table 4, we also added the graph of the "months of life" variable - Fig. A2. The test shows whether

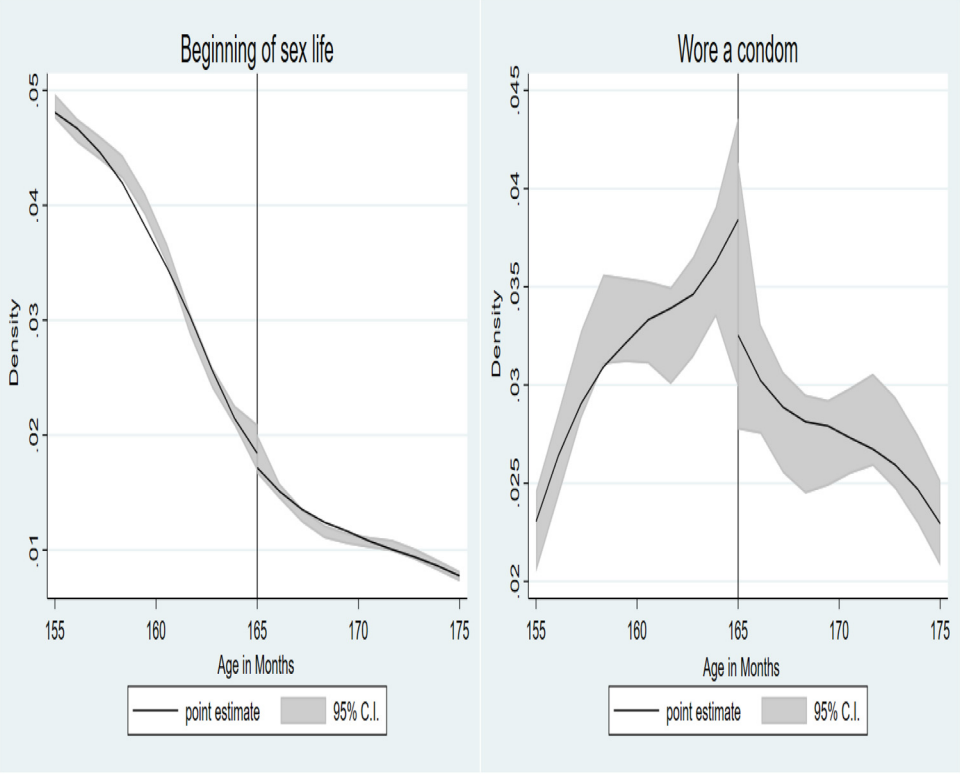

Fig. A2. Manipulation test around the discontinuity.

there is evidence that there is systematic manipulation of the girls' date of birth to enter or leave the treatment group. According to the figure, it is not possible to say that there is discontinuity around the cutoff in either analysis. This result is important, as it is a falsification test and shows that there is no evidence of manipulation of the running variable around the cutoff (Cattaneo et al., 2018; Cattaneo and Vazquez-Bare, 2016; Skovron and Titiunik, 2015).

6. Discussion

The finding is important for guiding public policies, since it contributes to dispelling the myth that there are incentives for beginning sexual life. There are no ex-ante moral hazard problems, as adolescents do not engage in risky behaviors such as beginning their sex life early because they are vaccinated (Moghtaderi and Dor, 2019). Regarding the beginning of sex life or risky sexual behavior, the literature points out that such decisions are not affected by the HPV vaccine (Bednarczyk et al., 2012; Liddon et al., 2012; Mayhew et al., 2014), in which the absence of significance of the second stage corroborates the causal literature (Moghtaderi and Dor, 2019; Smith et al., 2015).

In addition, it is an effective method for reducing cervical cancer, one of the types of cancer that most afflict the Brazilian female population. Evidence points to the need for awareness campaigns to stimulate the completion of the vaccine application cycle among adolescents for vaccination to be successful, as the literature points out that knowledge about the vaccine and the benefits of being correctly vaccinated are important predictors for the success of the vaccination program (Kim, 2015; Kwan et al., 2011; Wheldon et al., 2011).

The results prove to be important, since the campaign increased access to vaccination. Furthermore, it provides evidence to parents of the absence of a connection between this type of vaccine with the onset of sexual life. Therefore, the risk compensation theory (Adams, 1985), resulting from a greater exposure to risky sexual behaviors due to the safety provided by the vaccine (Brouwer et al., 2019; Donken et al., 2018), would not be observed, and this result is also verified by the non-reduction in the use of condoms (Forster et al., 2012).

Lack of knowledge on the association of human papillomavirus with cervical cancer is another drawback to a successful vaccination (Madhivanan et al., 2009). On the other hand, when young women believe they have contracted the virus, they are looking for the vaccine to prevent the types of virus – which offer a greater chance of turning into cancer (Roberts et al., 2010). Another point that increases the likelihood of vaccination of girls is when schools promote educational workshops on the benefits of immunization and the risks of the disease (Kwan et al., 2011), previous knowledge about the risks of the disease also increase the likelihood of vaccination (Wheldon et al., 2011).

However, parental opinion remains an important obstacle to the vaccine's effectiveness, since it is necessary to take more than the first dose. Parents who do not believe in the efficacy of the vaccine as well as those who believe in an increase in the propensity for risky sexual behavior due to vaccination are less encouraged to vaccinate their daughters (Bellia-Weiss et al., 2012; Forster et al., 2010). In a study carried out for the city of Juiz de Fora, Minas Gerais, Brazil, most parents proved to be aware of the safety of the HPV vaccine, as well as not associating it with risky sexual behaviors. However, they were opposed to the adolescent's independence in making decisions about vaccination. (Chehuen Neto et al., 2016).

Parents have a fundamental role in vaccination due to the age of the target audience, as they have the power to authorize or not vaccination of their children (Fonsêca et al., 2017). Awareness policies aimed at parents are effective in completing the vaccination cycle, reaching more than 90 % of the target audience in a study conducted in a city in the state of São Paulo (Fregnani et al., 2013). The state of Santa Catarina, in which 75 % of girls

received a vaccine, intensified the campaign in schools, with health workers visiting schools and talking to parents about the benefits of vaccination (França et al., 2017).

The media plays an important role in the dissemination of information. In addition, knowledge about HPV has gaps and is considered inadequate in several populations (Anhang et al., 2004; Cuschieri et al., 2006; Dahlström et al., 2012; Hansen and Schmidtblaicher, 2019; Klug et al., 2008; Zimet, 2005), and the role of the media prevails in comparison with professionals of the health services as a source of primary information on the human papilloma virus (Forster et al., 2010; Osis et al., 2014; Zimet et al., 2013). Within this context, Foster et al. (2010) show the existence of a growth in the discussion about HPV since the announcement of the vaccine development. This was demonstrated through 92 articles in different British newspapers between 2003 and 2008. Most newspapers are either neutral or support vaccination. For these cases, the argument is made, most of the time, using the opinion of experts. Those journals that are against vaccination adopt emotional tones, and parents who agree with the opinion issued by these newspapers, in general, do not believe in science or the government.

One limitation in the study is the fact that the database comprises girls who are in school, therefore, the effect may be different if young people outside the school environment are considered. Another limitation is that the database consists mostly of students in the 9th year of elementary school, however, the vaccine campaign is age-based, therefore, students who have been held back may behave differently.

7. Final Considerations

Vaccination against HPV in Brazil is not considered a successful case. This is because a lot of the girls were not getting the next doses of the vaccine – and another part did not even receive the first dose. There is a controversy surrounding such vaccination because it would encourage risky sexual behavior (such as not using condoms or having the first sexual intercourse early).

The present article aimed to test the regression discontinuity hypothesis, through a quasi-experimental method – that there is moral hazard when the girls take the vaccine. A possible causality between Human Papillomavirus (HPV) vaccination and beginning of sex life and, once girls have started sex life, between vaccination and condom use in the first intercourse, has been tested. The data used were from PeNSE (2015) and the vaccination campaign in 2014 was aimed at girls who had not reached the age of 14 in March of the respective year.

The results were consistent with the literature and showed that the vaccination campaign increases the likelihood of girls under 14 years taking the public HPV vaccine, but there are no significant effects on the beginning of sex life or condom use. The robustness and manipulation tests around the discontinuity corroborate the results and show that there was no manipulation of the birth date to receive the treatment, respectively.

Ethics approval and consent to participate

The survey was authorized by Brazilian's National Committee of Ethic in Research of the National Council of Health decision nº 1.006.467, which is responsible for regulating health research involving human beings. Microdata are freely available at IBGE website and makes impossible to identify the respondents. All procedures were in accordance with ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from all participants.

CRediT authorship contribution statement

Gustavo Saraiva Frio: Conceptualization, Data curation, Methodology, Writing - original draft, Writing - review & editing. **Marco Tulio Aniceto França:** Conceptualization, Supervision, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ehb.2020.100946.

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