DEMOGRAPHIC RESEARCH
A peer-reviewed, open-access journal of population sciences

*DEMOGRAPHIC RESEARCH*

**VOLUME 44, ARTICLE 37, PAGES 879–898**
**PUBLISHED 21 APRIL 2021**
http://www.demographic-research.org/Volumes/Vol44/37/
DOI:10.4054/DemRes.2021.44.37

*Research Article*

# Has contraceptive use at pregnancy an effect on the odds of spontaneous termination and induced abortion? Evidence from Demographic and Health Surveys

**David A. Sánchez-Páez**

**José Antonio Ortega**

# Contents

*Demographic Research*: Volume 44, Article 37
*Research Article*

# Has contraceptive use at pregnancy an effect on the odds of spontaneous termination and induced abortion? Evidence from Demographic and Health Surveys

**David A. Sánchez-Páez**[1]

**José Antonio Ortega**[2]


## Abstract

### BACKGROUND
Contraceptive failure increases the chances of pregnancy termination, including both induced abortions and spontaneous terminations. Proper separation requires accounting for competing risks of pregnancy outcomes.

### OBJECTIVE
To measure the differential risk of spontaneous termination and induced abortion according to contraceptive use prior to pregnancy based on pooled Demographic and Health Survey calendar data.

### METHODS
We use multinomial logistic models controlling for demographic and socioeconomic variables to estimate the differential risk of spontaneous termination and induced abortion according to contraceptive use at the time of pregnancy. We address data limitations including recall error, omission error, and possible misclassification of outcomes.

### RESULTS
We find higher risk of induced abortion (RRR = 7.18, CI = 6.38–8.09) and spontaneous termination (RRR = 1.38, CI = 1.13–1.69) after contraceptive failure, with stronger effect for women under 30. Parity, union status, education, and wealth have a strong effect on induced abortion. Regarding spontaneous termination, age mainly explains the increased risk.

### CONCLUSIONS
Since pregnancies following contraceptive failure are less likely to end in a live birth, aggregate models of the impact of family planning should reflect that contraceptive use

[1] Center for Demographic Research (DEMO), Université catholique de Louvain, Louvain-la-Neuve, Belgium. Email: david.sanchezpaez@uclouvain.be.
[2] Departmento de Economía e Historia Económica and IME, Universidad de Salamanca, Salamanca, Spain.

and induced abortion conform interdependent strategies and that spontaneous termination is a competing risk of induced abortion.

**CONTRIBUTION**

This is the first study reporting differences in the risk of spontaneous termination and induced abortion according to contraceptive use prior to pregnancy. We account for competing risks using a multinomial logit model of pregnancy outcomes conditional on pregnancy, new in the literature. Data limitations are addressed in novel ways.

## 1. Introduction

Fertility levels depend on the probability of pregnancies ending in a live birth. A comparative study found the proportion of pregnancies not ending in a live birth ranging between 4.9% and 52.0% in 20 countries, with induced abortion accounting for the highest values (Bradley, Croft, and Rutstein 2011). Pregnancy terminations include both spontaneous termination (ST) and induced abortion (IA).

The main role of contraception is to prevent pregnancy. Pregnancies occurring while using contraceptives are labeled as contraceptive failures and classified as unintended (Polis et al. 2016). Unintended pregnancies are more likely to end in IA (Bankole, Singh, and Haas 1998; Bradley, Croft, and Rutstein 2011). Non-users of contraception are more heterogeneous: they include both women who want to become pregnant and those who do not want pregnancy but cannot get contraception, having an unmet need for family planning (United Nations 2014). There is evidence of positive correlation between contraceptive failure and pregnancy termination (Sánchez-Páez and Ortega 2019), especially in the case of IA (Marston and Cleland 2004; Cleland 2020), but less is known regarding ST. Medical studies agree on the absence of causal effect of contraceptives on ST (Jellesen et al. 2008; Waller et al. 2010) but find behavioral differences in prenatal care leading to higher rates of ST (Cheng et al. 2009). Women whose pregnancies are unintended have been found less likely to seek antenatal care or to give up smoking during pregnancy (Kost, Landry, and Darroch 1998; Flower et al. 2013; Guliani, Sepehri, and Serieux 2013; Smedberg et al. 2014; Ulrich and Petermann 2016).

Besides contraception, other factors have been connected to both IA and ST, which should be considered when analyzing the effect of contraceptive use on pregnancy termination. In the case of IA, it is a choice associated with demographic characteristics (e.g., parity, marital status, age) and socioeconomic variables (e.g., education, wealth) (Ahmed and Ray 2014; Dickson, Adde, and Ahinkorah 2018; Maharana 2017; Souza e Silva et al. 2012). On the other hand, studies on ST, including both miscarriages and stillbirths, focus mainly on socioeconomic (e.g., education, wealth), biological (e.g., age, parity), or health (e.g., illness, antenatal care) determinants (Ahmed and Ray 2014; Mosley and Chen 2003; Nfii 2017).

A major methodological challenge is that live births, IA, and ST are competing outcomes. An early ST makes a subsequent IA not necessary, and some pregnancies ending in IA prevent a later ST (Potter, Ford, and Moots 1975; Meister and Schaefer 2008). Therefore, estimates based on the proportion of pregnancies ending in an outcome with no control for competing risks are biased. Different approaches have been proposed to address competing risk: a trivariate probit model treating IA, ST, and live birth as separate outcomes (Ahmed and Ray 2014); a multinomial logit to discriminate among IA decided by medical persons, IA decided by others, and ST, conditional on pregnancy termination (Maharana 2017); and a multinomial logit considering ST, IA, and ectopic pregnancy as outcomes, conditional on pregnancy termination (Schwandt et al. 2011). In our opinion, it is more natural to model the different pregnancy outcomes conditional on pregnancy for three reasons. First, only in this way it is possible to include pregnancy level covariates such as contraceptive use at pregnancy. Second, pregnancy termination occurs only in the context of an existent pregnancy, and third, contraceptive use at pregnancy carries with it a meaning of contraceptive failure that would not be present, for instance, in the trivariate logit model of unconditional risk. Then, contraceptive use has two different simultaneous effects: it reduces terminations by lowering the risk of pregnancy while increasing the probability of IA conditional on pregnancy since the pregnancy is unintended. Our interest in this research is not on the net effect but rather on the second effect on the probability of pregnancy outcomes.

Recent research linking contraceptive use and pregnancy termination has revealed that there is an increased risk of pregnancy termination when women are using contraceptives at the time they become pregnant (Sánchez-Páez and Ortega 2019); however, little is known in terms of the type of termination. Our study aims to fill the gap and assess the effect of using contraceptives at the time of pregnancy on the risk of ST and IA, accounting for the competing risk of pregnancy outcomes.

## 2. Data and methods

### 2.1 Data

Demographic and Health Surveys (DHS) have collected information on pregnancy histories, contraceptive use, marriage, fertility preferences, child mortality, education, and place of residence, among others, in developing countries since the 1980s (DHS Program 2020). In most cases, surveys include a contraceptive calendar going back up to 72 months before the interview (DHS Program 2017). In this monthly calendar, women report pregnancies, the outcome of those pregnancies (live birth or termination, which is our dependent variable), and contraceptive methods used. Thus, we can determine from the contraceptive calendar whether contraceptives were used at the time of becoming pregnant, which is our variable of interest. About the other covariates, from the pregnancy histories we calculate for each pregnancy the parity and number of previous terminations. Regarding union status, we use a marital status calendar when possible; otherwise, we impute it from current status and time and duration of the first union. Regarding age at birth, we group women by five-year age groups, except for those aged 40–49 due to the scarcity of pregnancies at those ages. Age at birth is equal to the mother's age at birth in pregnancies carried to term, and age at pregnancy plus nine months for terminated pregnancies. Thus, the age groups are comparable to those standard in fertility analysis. Information on education, wealth, employment, and place of residence refers to the time of the survey.

We use all available DHS meeting our requirements. They include a contraceptive calendar identifying the type of termination (ST or IA), pregnancy history, sample of not in union women, and other covariates (education, wealth, employment, place of residence). Unfortunately, most DHS do not report the type of termination, mainly because IA is highly restricted in most countries where DHS are collected. For this reason, the more than 250 DHS including calendar data in our potential sample are reduced to 23 surveys, with only 16 including all the covariates.

### 2.2 Data limitations

Since calendar data is collected retrospectively, there could be additional limitations, including recall error, omission error, and misclassification of outcomes. We address the potential role of these effects based on current knowledge and devise methods to limit their impact. Recall error in terminations has been identified in DHS by a systematic pattern of decline in events registered when going back in time (MacQuarrie et al. 2018). To address it, first, we limit our analysis to the most recent pregnancies to avoid data with worse deterioration problems together with displacement around the cut off year (Schoumaker 2014). Second, we include a recall error covariate in our analyses. This variable is defined as the distance in years between the month when the pregnancy started and the baseline month of nine months before the interview.

Omission errors differ by pregnancy outcome. Miscarriages, particularly those happening early in the pregnancy, can be missing due to ignorance of being pregnant, forgetting, or cultural differences. As for IA, it could be either reported as a miscarriage – misclassification – or omitted, especially in contexts where IA is highly restricted. On the other hand, evidence shows underreporting of stillbirths in DHS calendar data of some countries when compared to levels of early neonatal mortality (Bradley, Winfrey, and Croft 2015). Regarding omissions in contraceptive use, in many DHS the contraceptive prevalence estimated from the calendar data is lower than the rates obtained from current use from previous DHS (Bradley, Winfrey, and Croft 2015), suggesting that contraceptive use is underreported, which could bias our estimates downward, as some women who do not report use may have been using. As omissions increase over time, we address this problem by using the most recent pregnancies and only those DHS identified as consistent (Bradley, Winfrey, and Croft 2015; MacQuarrie et al. 2018).

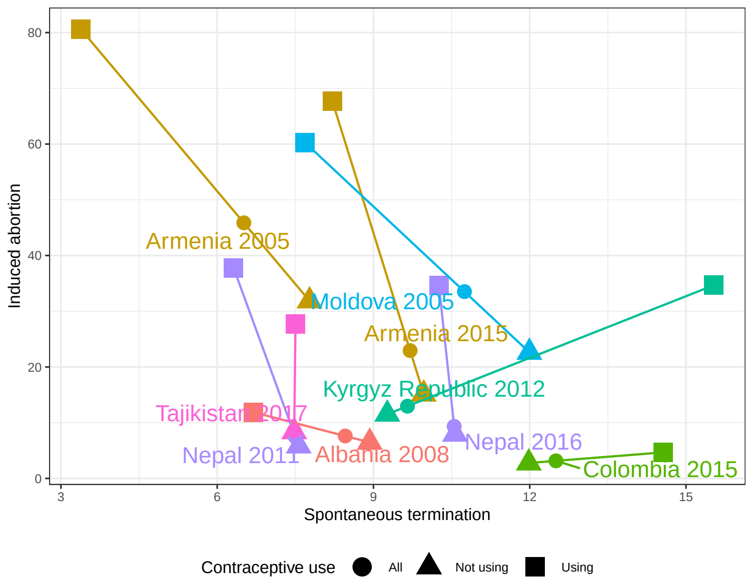
Regarding misclassification, one advantage of our data is that it can be detected by an abnormal increase in reported ST among contraceptive users. Since users are at higher risk of IA, this would suggest misclassification. We assess potential misclassification problems by looking at changes in the conditional probabilities of outcomes according to use. Figure 1 shows that the proportion of pregnancies ending in IA is higher than that of ST among contraceptive users in all DHS, except for Kyrgyz Republic 2012 and Colombia 2015. In these two surveys, an explanation in terms of IA reported as ST makes more sense than a large increase in the risk of ST. If the problem arises from a systematic misclassification according to contraceptive use, it can severely bias our estimates since a large proportion of reported ST could be IA. Otherwise, misreporting could be correlated with socioeconomic and cultural factors that might be captured through the model covariates. To avoid misclassification, we exclude both DHS from our sample.

After addressing the data limitations, our sample is reduced to seven DHS. Our sample includes individual-level information of 18,472 pregnancies that started in the period of 45 to 9 months before the interview (see Table 1). We exclude pregnancies starting in the eight months preceding the survey to avoid right censoring. This leaves us with an analysis period of 36 months.

### 2.3 Methods

A pregnancy can end either in birth, ST, or IA, with all three outcomes becoming competing risks. Ignoring the competing nature of risks leads to biased estimates of all risks (Potter, Ford, and Moots 1975; Meister and Schaefer 2008). In such multiple outcome situations, multinomial logit models provide consistent and efficient estimates when the assumption of independence of irrelevant alternatives (IIA) is met (Cheng and Long 2007). IIA implies that removing or adding an alternative does not alter the odds of the rest of the alternatives. IIA is met in our specific context to the extent that in the absence of IA the biological and behavioral risks for ST would still be there, and that the decision of IA is taken irrespective of the possibility of an ST. The two multinomial equations therefore have a clear separate interpretation, the first one – ST – as risk and the second one – IA – as choice, with the relative risk of IA vs. ST, which is not strategic, implicitly modeled as a competing risk.

**Figure 1: Percentage of pregnancies ending before live birth by contraceptive use (only DHS with consistent calendars are shown)**




First we estimate a baseline model by including only our variable of interest: contraceptive use at the time of pregnancy, i.e., pregnancy is the result of contraceptive failure. From there we estimate four other models. The first one adds the age groups. Since age gradients can be different for contraceptive users and non-users, the second model adds the interaction of contraceptive use and age group. The third adds women's demographic characteristics, such as marital status and reproductive history, summarized by parity and the number of previous terminations. This last variable captures differential risk for women who previously experienced terminations. Since there is little evidence supporting the causality of IA on subsequent ST, our interpretation in the case of ST is a biological predisposition, while for IA it would signal the acceptance of IA as a method to avoid unintended births. The fourth model adds the socioeconomic variables (education, wealth, employment, place of residence). All models include survey-level fixed effects and controls for recall error.

We carry out a sensitivity test based on a permutation experiment to ascertain the percentage of misclassification of pregnancy terminations of users required to replicate our baseline estimates under the null of no effect of use on ST.

## 3. Results

Table 1 provides the descriptive characteristics of the pregnancies in our sample. Pregnancy outcomes are distributed in 75.5% (n = 13,951) live births, 15.9% (n = 2,934) IA, and 8.6% (n = 1,586) ST. Pregnancies resulting from contraceptive failure represent 10.6% (n = 1,951) of the sample, and 37.7% (n = 735) of them end in live birth. The proportion of pregnancies ending in IA is 55.7% (n = 1,087) for users compared to only 11.2% (n = 1,847) for non-users. In contrast, the proportion of pregnancies ending in ST is smaller for users (6.6%, n = 128) than for non-users (8.8%, n = 1,458).

**Table 1: Characteristics of pregnancies and conditional probabilities of outcomes**

| | Total pregnancies | | Percentage ending in termination | | | |
|---|---|---|---|---|---|---|
| | Total | % of n | Birth | Spontaneous | Induced | p-value |
| **Sample** | | | | | | |
| Pregnancies (n) | 18,472 | 100.0 | 75.5 | 8.6 | 15.9 | |
| **Surveys** | | | | | | |
| Albania 2008 | 1,049 | 5.7 | 83.9 | 8.5 | 7.6 | < 0.001 |
| Armenia 2005 | 1,848 | 10.0 | 47.6 | 6.5 | 45.9 | |
| Armenia 2015 | 1,559 | 8.4 | 67.4 | 9.7 | 22.9 | |
| Moldova 2005 | 1,851 | 10.0 | 55.7 | 10.8 | 33.5 | |
| Nepal 2011 | 3,804 | 20.6 | 85.0 | 7.5 | 7.5 | |
| Nepal 2016 | 3,797 | 20.6 | 80.1 | 10.6 | 9.3 | |
| Tajikistan 2017 | 4,563 | 24.7 | 84.0 | 7.5 | 8.5 | |
| **Contraceptive use** | | | | | | |
| Non-users | 16,521 | 89.4 | 80.0 | 8.8 | 11.2 | < 0.001 |
| Users | 1,951 | 10.6 | 37.7 | 6.6 | 55.7 | |
| **Union status** | | | | | | |
| In union | 18,057 | 97.8 | 75.7 | 8.6 | 15.8 | 0.123 |
| Not in union | 415 | 2.2 | 69.9 | 9.5 | 20.5 | |
| **Age group** | | | | | | |
| < 20 | 2,436 | 13.2 | 85.2 | 10.8 | 4.0 | < 0.001 |
| 20–24 | 6,814 | 36.9 | 82.9 | 7.6 | 9.5 | |
| 25–29 | 5,156 | 27.9 | 73.1 | 8.3 | 18.6 | |
| 30–34 | 2,596 | 14.1 | 65.7 | 8.1 | 26.2 | |
| 35–39 | 1,122 | 6.1 | 54.2 | 9.8 | 35.9 | |
| 40–49 | 347 | 1.9 | 42.2 | 15.9 | 41.9 | |
| **Parity** | | | | | | |
| 0 | 6,011 | 32.5 | 86.8 | 10.3 | 2.9 | < 0.001 |
| 1 | 5,277 | 28.6 | 81.0 | 8.3 | 10.8 | |
| 2 | 3,863 | 20.9 | 61.5 | 7.0 | 31.5 | |
| 3 | 1,822 | 9.9 | 61.6 | 6.8 | 31.7 | |

**Table 1: Continued**

| | **Total pregnancies** | | **Percentage ending in termination** | | | |
|---|---|---|---|---|---|---|
| | Total | % of n | Birth | Spontaneous | Induced | p-value |
| **Parity** | | | | | | |
| 4 | 783 | 4.2 | 61.7 | 6.9 | 31.4 | |
| 5 | 394 | 2.1 | 67.5 | 9.7 | 22.9 | |
| 6+ | 320 | 1.7 | 66.4 | 13.9 | 19.8 | |
| **Previous terminations** | | | | | | |
| 0 | 11,033 | 59.7 | 81.1 | 8.6 | 10.3 | < 0.001 |
| 1 | 3,565 | 19.3 | 70.6 | 8.2 | 21.2 | |
| 2 | 1,754 | 9.5 | 67.6 | 9.2 | 23.2 | |
| 3 | 958 | 5.2 | 65.2 | 9.3 | 25.5 | |
| 4+ | 1,162 | 6.3 | 58.1 | 7.8 | 34.1 | |
| **Level of education** | | | | | | |
| No education | 2,898 | 15.7 | 85.8 | 8.1 | 6.1 | < 0.001 |
| Primary | 2,629 | 14.2 | 81.2 | 8.8 | 9.9 | |
| Secondary | 9,739 | 52.7 | 72.1 | 8.2 | 19.7 | |
| Higher | 3,206 | 17.4 | 72.0 | 10.0 | 18.0 | |
| **Place of residence** | | | | | | |
| Urban | 6,610 | 35.8 | 69.1 | 9.6 | 21.3 | < 0.001 |
| Rural | 11,862 | 64.2 | 79.1 | 8.0 | 12.9 | |
| **Currently working** | | | | | | |
| No | 12,192 | 66.0 | 77.6 | 8.1 | 14.3 | < 0.001 |
| Yes | 6,280 | 34.0 | 71.5 | 9.6 | 18.9 | |
| **Wealth quintile** | | | | | | |
| Quintile 1 | 3,761 | 20.4 | 77.9 | 8.1 | 14.0 | < 0.001 |
| Quintile 2 | 3,796 | 20.6 | 77.0 | 8.3 | 14.7 | |
| Quintile 3 | 3,844 | 20.8 | 78.8 | 7.9 | 13.3 | |
| Quintile 4 | 3,768 | 20.4 | 74.4 | 9.1 | 16.5 | |
| Quintile 5 | 3,303 | 17.9 | 68.7 | 9.6 | 21.6 | |

*Note*: Excluded DHS due to missing covariates are Armenia 2000, Kazakhstan 1999, Philippines 1998, Turkey 1993, Turkey 1998, Vietnam 1997, and Vietnam 2002. Excluded DHS due to potential misclassification errors are Colombia 2015 and Kyrgyz Republic 2012. Excluded DHS due to inconsistency are Armenia 2010, Azerbaijan 2006, Indonesia 2012, Philippines 2003, Tajikistan 2012, Turkey 2003, and Ukraine 2007.

Table 2 presents estimates of relative risk ratios (RRR) and 95% confidence intervals (CI, here presented in brackets) from the baseline model. Regression from the selected sample shows that users have a higher RRR of experiencing ST – 1.38 [1.13–1.69] – than non-users. Likewise, users recur more frequently to IA in a ratio of 7.18 [6.38–8.09]. On the right of Table 2, we present the baseline model including the 23 DHS – a potential sample including possibly inconsistent data. Estimates show similar coefficients to those of the consistent sample: RRR = 7.25 [6.84–7.68] for IA and RRR = 1.31 [1.22–1.41] for ST. In this respect, it seems that our findings are robust and could be generalized to other countries.

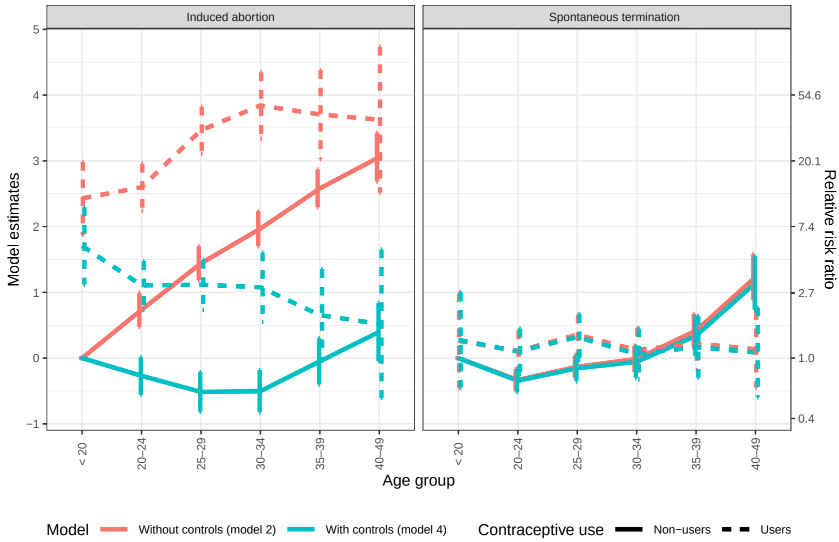
**Table 2: Relative risk ratios (RRR) from baseline model, using multinomial logistic regression accounting for competing risk (Birth is the reference)**

| | Selected sample | | | | Potential sample | | | |
|---|---|---|---|---|---|---|---|---|
| | Spontaneous | | Induced | | Spontaneous | | Induced | |
| | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI |
| **Contraceptive use** | | | | | | | | |
| Non-users | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Users | 1.38 | 1.13–1.69 | 7.18 | 6.38–8.09 | 1.31 | 1.22–1.41 | 7.25 | 6.84–7.68 |
| **Recall error** | | | | | | | | |
| Per year | 0.93 | 0.87–0.98 | 0.93 | 0.88–0.98 | 0.95 | 0.92–0.97 | 0.96 | 0.93–0.98 |
| **Fixed effect** | | | | | | | | |
| Survey | | yes | | yes | | yes | | yes |

A replication experiment provides an additional sensitivity test of the extent to which the positive coefficient of use on ST could be due to missclassification of outcomes among users. We have randomly switched a fraction of declared ST to IA among users to ascertain the level of misclassification required to shrink the estimated effect to zero. In the case of the selected sample, 21.5% of ST would have to be switched, and 24.8% of the potential sample.

Table 3 shows the models progressively introducing controls for demographic and socioeconomic variables into the baseline model. Controlling for age (model 1) leads to lower estimates of contraceptive use compared to the baseline model for both ST (RRR = 1.4, CI = 1.1–1.7) and IA (RRR = 6.3, CI = 5.5–7.1). Age gradients show V-shaped trends in the case of ST, with minimum risk at ages 20–24, and increasing with age for IA, suggesting that older women are more at risk of induced abortion.

**Figure 2: Estimated age profiles of pregnancy outcomes according to contraceptive use without (model 2) and with (model 4) control for demographic and socioeconomic characteristics**




*Note*: Asymptotic 95% confidence intervals are displayed in vertical.

Coefficients for interacted variables in models 2 to 4 are best interpreted collectively in Figure 2. Only models 2 and 4 are shown due to the similarity of models 3 and 4. Regarding IA, model 2, with no controls, shows that the risk increases with age for both users and non-users. In contrast, model 4 shows relatively flat decreasing patterns with maximum levels for younger women in the case of users, and a U-shaped pattern with minimum levels at ages 25–34 for non-users. The large reduction in the coefficients is mostly connected to the effects of parity and union status, with women at high parities much more likely to recur to IA. Controlling for parity, model 4 suggests that younger women experiencing contraceptive failure are more likely to recur to IA. Regarding ST, there are differences by contraceptive use. For users, there is higher risk among women aged 25–29, while for non-users, the risk increases with age from ages 20–24. Controlling for demographic and socioeconomic characteristics has little impact on the age patterns.

**Table 3: Relative risk ratios (RRR) from multinomial logistic regression, accounting for competing risk (birth is the reference)**

| | Model 1 | | | | Model 2 | | | | Model 3 | | | | Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spontaneous | | Induced | | Spontaneous | | Induced | | Spontaneous | | Induced | | Spontaneous | | Induced | |
| | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI |
| **Contraceptive use** | | | | | | | | | | | | | | | | |
| Non-users | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| Users | 1.4 | 1.1–1.7 | 6.3 | 5.5–7.1 | 1.3 | 0.6–2.7 | 11.3 | 6.5–19.8 | 1.4 | 0.7–2.8 | 5.8 | 3.2–10.4 | 1.3 | 0.6–2.7 | 5.5 | 3.1–9.9 |
| **Age group** | | | | | | | | | | | | | | | | |
| < 20 | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| 20–24 | 0.7 | 0.6–0.9 | 1.9 | 1.5–2.4 | 0.7 | 0.6–0.8 | 2.1 | 1.6–2.7 | 0.7 | 0.6–0.9 | 0.9 | 0.6–1.1 | 0.7 | 0.6–0.8 | 0.8 | 0.6–1.0 |
| 25–29 | 0.9 | 0.8–1.1 | 3.9 | 3.1–4.9 | 0.9 | 0.7–1.0 | 4.2 | 3.3–5.5 | 0.9 | 0.8–1.1 | 0.8 | 0.6–1.0 | 0.9 | 0.7–1.0 | 0.6 | 0.4–0.8 |
| 30–34 | 1.0 | 0.8–1.2 | 6.5 | 5.1–8.2 | 1.0 | 0.8–1.2 | 7.2 | 5.5–9.4 | 1.1 | 0.9–1.4 | 0.9 | 0.6–1.2 | 0.9 | 0.7–1.2 | 0.6 | 0.4–0.8 |
| 35–39 | 1.5 | 1.1–1.9 | 10.5 | 8.1–13.5 | 1.5 | 1.2–2.0 | 13.2 | 9.9–17.6 | 1.6 | 1.2–2.2 | 1.5 | 1.1–2.1 | 1.4 | 1.0–1.9 | 1.0 | 0.7–1.4 |
| 40–49 | 3.0 | 2.1–4.2 | 15.2 | 10.9–21.3 | 3.4 | 2.4–4.9 | 21.3 | 14.7–30.8 | 3.7 | 2.5–5.5 | 2.4 | 1.5–3.6 | 3.1 | 2.1–4.7 | 1.5 | 1.0–2.3 |
| **Use x age group** | | | | | | | | | | | | | | | | |
| Users x < 20 | | | | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| Users x 20–24 | | | | | 1.2 | 0.5–2.6 | 0.6 | 0.3–1.0 | 1.2 | 0.5–2.6 | 0.7 | 0.4–1.4 | 1.2 | 0.5–2.6 | 0.7 | 0.4–1.4 |
| Users x 25–29 | | | | | 1.3 | 0.6–2.8 | 0.7 | 0.4–1.2 | 1.2 | 0.5–2.7 | 1.0 | 0.5–1.8 | 1.2 | 0.5–2.7 | 0.9 | 0.5–1.7 |
| Users x 30–34 | | | | | 0.9 | 0.4–2.1 | 0.6 | 0.3–1.1 | 0.8 | 0.4–2.0 | 0.9 | 0.5–1.7 | 0.9 | 0.4–2.1 | 0.9 | 0.5–1.7 |
| Users x 35–39 | | | | | 0.6 | 0.2–1.7 | 0.3 | 0.1–0.5 | 0.6 | 0.2–1.7 | 0.4 | 0.2–0.7 | 0.6 | 0.2–1.7 | 0.4 | 0.2–0.7 |
| Users x 40–49 | | | | | 0.3 | 0.1–1.0 | 0.2 | 0.1–0.4 | 0.3 | 0.1–1.0 | 0.2 | 0.1–0.5 | 0.3 | 0.1–1.0 | 0.2 | 0.1–0.5 |
| **Union status** | | | | | | | | | | | | | | | | |
| Not in union | | | | | | | | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| In union | | | | | | | | | 0.9 | 0.7–1.3 | 0.2 | 0.1–0.3 | 0.9 | 0.7–1.3 | 0.2 | 0.1–0.3 |
| **Parity** | | | | | | | | | | | | | | | | |
| 0 | | | | | | | | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| 1 | | | | | | | | | 0.8 | 0.7–1.0 | 4.0 | 3.3–5.0 | 0.9 | 0.8–1.0 | 4.6 | 3.7–5.7 |
| 2 | | | | | | | | | 0.9 | 0.8–1.1 | 16.3 | 13.1–20.4 | 1.0 | 0.9–1.2 | 23.4 | 18.6–29.4 |
| 3 | | | | | | | | | 0.9 | 0.7–1.1 | 21.5 | 16.7–27.6 | 1.0 | 0.8–1.3 | 38.2 | 29.3–49.9 |
| 4 | | | | | | | | | 0.9 | 0.6–1.2 | 24.4 | 18.2–32.5 | 1.0 | 0.7–1.4 | 52.3 | 38.4–71.2 |
| 5 | | | | | | | | | 0.9 | 0.6–1.4 | 16.8 | 11.7–24.1 | 1.1 | 0.8–1.7 | 46.7 | 31.7–68.9 |
| 6+ | | | | | | | | | 1.2 | 0.8–1.8 | 13.5 | 9.0–20.1 | 1.5 | 1.0–2.3 | 45.2 | 29.4–69.5 |

**Table 3: Continued**

| | Model 1 | | | | Model 2 | | | | Model 3 | | | | Model 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spontaneous | | Induced | | Spontaneous | | Induced | | Spontaneous | | Induced | | Spontaneous | | Induced | |
| | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI | RRR | 95% CI |
| **Previous terminations** | | | | | | | | | | | | | | | | |
| 0 | | | | | | | | | 1.0 | | 1.0 | | 1.0 | | 1.0 | |
| 1 | | | | | | | | | 0.9 | 0.7–1.0 | 2.0 | 1.8–2.3 | 0.9 | 0.7–1.0 | 2.0 | 1.7–2.2 |
| 2 | | | | | | | | | 1.0 | 0.8–1.3 | 2.0 | 1.7–2.4 | 1.0 | 0.8–1.3 | 1.8 | 1.5–2.1 |
| 3 | | | | | | | | | 1.0 | 0.7–1.3 | 1.7 | 1.4–2.2 | 1.0 | 0.8–1.3 | 1.7 | 1.4–2.2 |
| 4+ | | | | | | | | | 0.7 | 0.6–1.0 | 1.6 | 1.3–2.0 | 0.8 | 0.6–1.0 | 1.8 | 1.4–2.2 |
| **Level of education** | | | | | | | | | | | | | | | | |
| No education | | | | | | | | | | | | | 1.0 | | 1.0 | |
| Primary | | | | | | | | | | | | | 1.3 | 1.0–1.6 | 2.7 | 2.1–3.4 |
| Secondary | | | | | | | | | | | | | 1.2 | 1.0–1.5 | 4.7 | 3.7–5.9 |
| Higher | | | | | | | | | | | | | 1.2 | 0.9–1.5 | 3.9 | 3.0–5.1 |
| **Place of residence** | | | | | | | | | | | | | | | | |
| Urban | | | | | | | | | | | | | 1.0 | | 1.0 | |
| Rural | | | | | | | | | | | | | 1.0 | 0.8–1.1 | 0.9 | 0.8–1.0 |
| **Wealth quintile** | | | | | | | | | | | | | | | | |
| Quintile 1 | | | | | | | | | | | | | 1.0 | | 1.0 | |
| Quintile 2 | | | | | | | | | | | | | 1.1 | 0.9–1.3 | 1.4 | 1.2–1.7 |
| Quintile 3 | | | | | | | | | | | | | 1.0 | 0.9–1.2 | 1.5 | 1.3–1.8 |
| Quintile 4 | | | | | | | | | | | | | 1.3 | 1.1–1.5 | 1.9 | 1.6–2.3 |
| Quintile 5 | | | | | | | | | | | | | 1.4 | 1.1–1.7 | 2.6 | 2.2–3.2 |
| **Currently working** | | | | | | | | | | | | | | | | |
| No | | | | | | | | | | | | | 1.0 | | 1.0 | |
| Yes | | | | | | | | | | | | | 1.3 | 1.2-1.5 | 1.8 | 1.6–2.1 |
| **Recall error** | | | | | | | | | | | | | | | | |
| Per year | 0.9 | 0.9–1.0 | 0.9 | 0.9–1.0 | 0.9 | 0.9–1.0 | 0.9 | 0.9–1.0 | 0.9 | 0.9–1.0 | 0.9 | 0.9–1.0 | 0.9 | 0.9–1.0 | 0.9 | 0.9–1.0 |
| **Fixed effects** | | | | | | | | | | | | | | | | |
| Survey | | yes | | yes | | yes | | yes | | yes | | yes | | yes | | yes |

Regarding the rest of the variables in Table 3, a higher number of previous terminations is connected with a higher risk only in the case of IA. According to level of education, women with no education have lower risk of both IA and ST. The risk of IA presents an inverted U-shaped pattern, while the risk of ST is similar for all education levels. Wealth quintiles show higher risk of termination for richer women, especially for IA. Women currently working are also more likely to experience terminations, with stronger effects for IA. There are no differences in the risk by place of residence. Recall error seems to be present in all cases, with estimates of comparable magnitude for ST and IA.

## 4. Discussion

This study presents original estimates of the differential risk of ST and IA according to contraceptive use at pregnancy using, for the first time in this context, a multinomial logit model for pregnancy outcomes conditional on pregnancy. It is also the first comparative study making use of the information contained in DHS calendar data. Since some DHS have showed inconsistencies in calendar data, we have used only surveys meeting all our quality requirements, ruling out those with suspected or confirmed unreliability. Moreover, we have used controls to minimize potential biases due to common problems when collecting retrospective data.

The share of pregnancies not ending in live birth in our sample is within the ranges reported in the literature (Bradley, Croft, and Rutstein 2011; Sánchez-Páez and Ortega 2019). At the survey level, pregnancy termination ranges between 15.0% and 52.4%, with the incidence of IA explaining most of the differences. Consistent with previous findings (Bankole, Singh, and Haas 1998; Bradley, Croft, and Rutstein 2011; Marston and Cleland 2004; Sánchez-Páez and Ortega 2019), our estimates show a link between contraceptive failure and pregnancy termination, not only by IA but also by ST. Although contraceptive use has increased in the last decades, there is still a large share of pregnancies considered as unintended, many due to contraceptive failure (Polis et al. 2016). Regarding ST, since medical studies do not find a causal effect of contraceptive use on miscarriages, one explanation for the increased risk could be a difference in antenatal behavior when the pregnancy results from contraceptive failure (Kost, Landry, and Darroch 1998; Flower et al. 2013; Guliani, Sepehri, and Serieux 2013; Smedberg et al. 2014; Ulrich and Petermann 2016). Nevertheless, age appears as the main determinant for ST even after including controls. This result is subject to bias if IA is misclassified as ST. The small change in patterns of ST by age after introducing controls, in contrast to IA, suggests that misclassification is not that important. Misclassification would have to be very intense, more than 20% of declared ST and only among users, to explain the estimates if there were really no effect. Further research is needed.

Including demographic and socioeconomic variables, in particular age gradients by use, has allowed us to identify combined strategies of contraceptive use and IA in birth prevention. After controls, parity and union status become more relevant than age on the decision to abort. Regarding ST, age gradients seem more connected to biological factors than to behavioral factors, especially at older ages. More educated women living in urban areas with a higher wealth status are more likely to recur to IA, since they might have better access and be more knowledgeable of available options (Lesthaeghe and Vanderhoeft 2001; Westoff 2005). In the case of ST, we find patterns of higher risk for nulliparous women.

Our sample includes exclusively countries where laws about IA are less restrictive and that share certain historical and political characteristics. In this context, previous research has argued that in Armenia, Kazakhstan, and Nepal, contraception and abortion act as substitutes, increasing the odds of IA (Westoff 2000; Westoff et al. 2002; Miller and Valente 2016). In order to evaluate the external validity of our results, we have provided estimates for a more diverse sample of countries where there could be concerns regarding the reliability of the data. We obtain results that are qualitatively the same as, and quantitatively very similar to, those obtained using only data known to be consistent.

Our research has implications regarding methods for estimating the impact of contraceptive use on abortion and pregnancy outcomes. A first implication is that contraceptive use and IA are dependent strategies, and this perspective should be used in models intended to provide IA estimates (Cleland 2020). Second, since IA and ST are competing risks, scenarios that change one probability while keeping the other constant are not realistic. That is the case with many aggregate models, partly due to little evidence on ST.

## 5. Acknowledgments

David A. Sánchez-Páez wants to acknowledge that the earliest version of this study was conducted while he was enrolled at the Doctoral Program in Economics, Universidad de Salamanca. José Antonio Ortega acknowledges partial funding through grant SA049G19 (Junta de Castilla y León).

## References

Ahmed, S. and Ray, R. (2014). Determinants of pregnancy, induced and spontaneous abortion in a jointly determined framework: Evidence from a country-wide, district-level household survey in India. *Journal of Biosocial Science* 46(4): 480–517. doi:10.1017/S0021932013000369.

Bankole, A., Singh, S., and Haas, T. (1998). Reasons why women have induced abortions: Evidence from 27 countries. *International Family Planning Perspectives* 24(3): 117–127. doi:10.2307/3038208.

Bradley, S., Croft, T., and Rutstein, S.O. (2011). The impact of contraceptive failure on unintended births and induced abortions: Estimates and strategies for reduction. Calverton: ICF Macro (DHS Analytical Studies 22).

Bradley, S., Winfrey, W., and Croft, T.N. (2015). Contraceptive use and perinatal mortality in the DHS: An assessment of the quality and consistency of calendars and histories. Rockville: ICF International (DHS Methodological Reports 17).

Cheng, D., Schwarz, E.B., Douglas, E., and Horon, I. (2009). Unintended pregnancy and associated maternal preconception, prenatal and postpartum behaviors. *Contraception* 79(3): 194–198. doi:10.1016/j.contraception.2008.09.009.

Cheng, S. and Long, J.S. (2007). Test for IIA in the multinomial logit model. *Sociological Methods and Research* 35(4): 583–600. doi:10.1177/0049124106292361.

Cleland, J. (2020). The complex relationship between contraception and abortion. *Best Practice and Research Clinical Obstetrics and Gynaecology* 62: 90–100. doi:10.1016/j.bpobgyn.2019.04.007.

de Souza e Silva, R., Mendes de Oliveira Carneiro, C., Drezett, J., and Andreoni, S. (2012). Prevalence and characteristics of women with a history of abortion among women who became pregnant. *Journal of Human Growth and Development* 22(1): 27–33. doi:10.7322/jhgd.20046.

DHS Program (2017). DHS contraceptive calendar tutorial [electronic resource]. Rockville: Demographic and Health Surveys (DHS) Program. https://www.dhsprogram.com/data/calendar-tutorial/upload/DHS-Contraceptive-Calendar-Tutorial.pdf.

DHS Program (2020). Demographic and Health Surveys (DHS) [electronic resource]. Rockville: Demographic and Health Surveys Program. dhsprogram.com/Data/.

Dickson, K.S., Adde, K.S., and Ahinkorah, B. (2018). Socio-economic determinants of abortion among women in Mozambique and Ghana: Evidence from demographic and health surveys. *Archives of Public Health* 76(37): 36–46. doi:10.1186/s13690-018-

0286-0.

Flower, A., Shawe, J., Stephenson, J., and Doyle, P. (2013). Pregnancy planning, smoking behaviour during pregnancy, and neonatal outcome: UK millennium cohort study. *BMC Pregnancy and Childbirth* 13(1): 238–244. doi:10.1186/1471-2393-13-238.

Guliani, H., Sepehri, A., and Serieux, J. (2013). Determinants of prenatal care use: Evidence from 32 low-income countries across Asia, sub-Saharan Africa and Latin America. *Health Policy and Planning* 29(5): 589–602. doi:10.1093/heapol/czt045.

Jellesen, R., Stransberg-Larsen, K., Jorgensen, T., Olsen, J., Thulstrup, A.M., and Andersen, A.M. (2008). Maternal use of oral contraceptives and risk of fetal death. *Paediatric and Perinatal Epidemiology* 22(4): 334–340. doi:10.1111/j.1365-3016.2008.00942.x.

Kost, K., Landry, D.J., and Darroch, J.E. (1998). Predicting maternal behaviors during pregnancy: Does intention status matter? *Family Planning Perspectives* 30(2): 79–88. doi:10.1363/3007998.

Lesthaeghe, R. and Vanderhoeft, C. (2001). Ready, willing and able: A conceptualization of transitions to new behavioural forms. In: Casterline, J.B. (ed.). *Diffusion processes and fertility transition. Selected perspectives*. Washington: National Academy Press: 240–264.

MacQuarrie, K.L.D., Winfrey, W., Meijer-Irons, J., and Roback Morse, A. (2018). Consistency of reporting of terminated pregnancies in DHS calendars. Rockville: ICF (DHS Metodological Reports 25).

Maharana, B. (2017). Abortion decision making in India: Whose role is vital? *Social Science Spectrum* 2(4): 263–274.

Marston, C. and Cleland, J. (2004). The effects of contraception on obstetric outcomes. Geneva: Department of Reproductive Health and Research, World Health Organization.

Meister, R. and Schaefer, C. (2008). Statistical methods for estimating the probability of spontaneous abortion in observational studies: Analyzing pregnancies exposed to coumarin derivatives. *Reproductive Toxicology* 26(1): 31–35. doi:10.1016/j.reprotox.2008.06.006.

Miller, G. and Valente, C. (2016). Population policy: Abortion and modern contraception are substitutes. *Demography* 53(4): 979–1009. doi:10.1007/s13524-016-0492-8.

Mosley, W.H. and Chen, L.C. (2003). An analytical framework for the study of child survival in developing countries: Public health classics. *International Journal of Public Health* 81(2): 140–145. doi:10.2307/2807954.

Nfii, F.N. (2017). Levels, trends and household determinants of stillbirths and miscarriages among women aged 15-49 years in South Africa [MA Thesis]. Johannesburg: University of Witwatersrand, Faculties of Health Sciences and Humanities.

Polis, C.B., Bradley, S.E.K., Bankole, A., Onda, T., Croft, T., and Singh, S. (2016). Typical-use contraceptive failure rates in 43 countries with demographic and health survey data: Summary of a detailed report. *Contraception* 94(1): 11–17. doi:10.1016/j.contraception.2016.03.011.

Potter, R.G., Ford, K., and Moots, B. (1975). Competition between spontaneous and induced abortion. *Demography* 12(1): 129–141. doi:10.2307/2060738.

Schoumaker, B. (2014). Quality and consistency of DHS fertility estimates, 1990 to 2012. Rockville: ICF International (DHS Methodological Reports 12).

Schwandt, H.M., Creanga, A.A., Danso, K.A., Adanu, R.M.K., Agbenyega, T., and Hindin, M.J. (2011). A comparison of women with induced abortion, spontaneous abortion and ectopic pregnancy in Ghana. *Contraception* 84(1): 87–93. doi:10.1016/j.contraception.2010.10.011.

Smedberg, J., Lupattelli, A., Mårdby, A.C., and Nordeng, H. (2014). Characteristics of women who continue smoking during pregnancy: A cross-sectional study of pregnant women and new mothers in 15 European countries. *BMC Pregnancy and Childbirth* 14(1): 213–228. doi:10.1186/1471-2393-14-213.

Sánchez-Páez, D.A. and Ortega, J.A. (2019). Reported patterns of pregnancy termination from Demographic and Health Surveys. *PLoS ONE* 14(8): e0221178. doi:10.1371/journal.pone.0221178.

Ulrich, F. and Petermann, F. (2016). Consequences and possible predictors of health-damaging behaviors and mental health problems in pregnancy: A review. *Geburtshilfe und Frauenheilkunde* 76(11): 1136–1156. doi:10.1055/jhgd.s-0042-118180.

United Nations (2014). World contraceptive use. New York: United Nations, Department of Economic and Social Affairs, Population Division. https://www.un.org/en/development/desa/population/publications/dataset/contraception/wcu2014.asp.

Waller, D., Gallaway, M., Taylor, L., Ramadhani, T., Canfield, M., Scheuerle, A., Hernández-Díaz, S., Louik, C., and Correa, A. (2010). Use of oral contraceptives in pregnancy and major structural birth defects in offspring. *Epidemiology* 21(2): 232–239. doi:10.1097/EDE.0b013e3181c9fbb3.

Westoff, C. (2000). The substitution of contraception for abortion in Kazakhstan in the 1990s. Calverton: ORC Macro (DHS Analytical Studies Series 1).

Westoff, C. (2005). Recent trends in abortion and contraception in 12 countries. Calverton: ORC Macro (DHS Analytical Studies 8).

Westoff, C., Sullivan, J.M., Newby, H.A., and Themme, A.R. (2002). Contraception–abortion connections in Armenia. Calverton: ORC Macro (DHS Analytical Studies Series 6).