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

DEMOGRAPHIC RESEARCH

VOLUME 38, ARTICLE 45, PAGES 1359–1388
PUBLISHED 18 APRIL 2018
http://www.demographic-research.org/Volumes/Vol38/45/
DOI: 10.4054/DemRes.2018.38.45

Research Article

Adolescent contraceptive use and its effects on fertility

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Demographic Research: Volume 38, Article 45
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Abstract

BACKGROUND
Adolescent reproductive health is part of internationally agreed development goals. Unmarried adolescents are not commonly included in global monitoring of contraceptive use despite the more severe consequences of unintended childbearing for them.

OBJECTIVE
We document levels and trends of contraceptive prevalence and demand for married and sexually active unmarried adolescent women aged 15–19 in Latin America and sub-Saharan Africa. We estimate the effect of adolescent contraceptive use and marital status on fertility and the impact of meeting current demand.

METHODS
We propose a fertility model informed by the proximate determinants framework separating adolescents by marital status. Linear Mixed Model estimates are based on aggregate data from 120 DHS surveys for 34 developing countries.

RESULTS
Increasing contraceptive prevalence has already reduced adolescent fertility by 6.8% in Latin America and 4.1% in sub-Saharan Africa. Meeting the total demand for contraceptives of unmarried adolescents would lead to an additional decrease in fertility of 8.9% and 17.4% respectively.

CONCLUSIONS
Contraceptive demand and prevalence are generally higher for sexually active unmarried adolescent women than for those married. Increasing prevalence has already had an impact in declining fertility, but there is a potentially larger effect if high levels of unmet need are eliminated, particularly in sub-Saharan Africa. Such reduction would have a significant impact on adolescent health.

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CONTRIBUTION

We provide evidence of the importance of contraceptive use of unmarried sexually active adolescent women in explaining trends in adolescent fertility. We estimate the potential effect of meeting the contraceptive needs of married and unmarried adolescents on unintended childbearing.

1. Background

Total demand and contraceptive use are fundamental measures of access to Sexual and Reproductive Health and Rights (SRHR). Universal access to Sexual and Reproductive Health (SRH) by 2030 corresponds to targets 3.7 and 5.6 of the United Nations Sustainable Development Goals (SDGs), and it is also recognized in target 5.B of the Millennium Development Goals (UN 2015). In fact, indicator 3.7.2 of the SDGs explicitly refers to Adolescent Birth Rate. Expansion of contraceptive use in most impoverished countries is also the goal of the Family Planning 2020 global partnership (Family Planning 2020 2015). Not leaving adolescents behind is explicit in the Global Strategy for Women's, Children's and Adolescents' Health of the Every Woman Every Child global movement (Every Woman Every Child 2015). Following international practice, the key measure of adolescent fertility is the age-specific fertility rate for women aged 15 to 19 (UN 2013). At present, about sixteen million young women between ages from 15 to 19 give birth every year, and three million undergo unsafe abortions, making pregnancy and childbirth the leading cause of death for teenage girls (Advocates for Youth 2013). Approximately 11% of global births occur to adolescent women, 95% of them in developing countries (Vogel et al. 2015; WHO 2011).

Despite the mention to universal access, global monitoring of these aims has centered on women married or in-union (UN 2016; UNFPA 2010). As a result, groups with special needs, such as sexually active unmarried adolescent women, are often left out of sight. Based on available global data on contraceptive use of adolescents, we bring into the debate the specific effect of contraception of sexually active unmarried adolescents on adolescent fertility. It is a factor of increasing importance to the extent that marriage is postponed with an increasing gap between sexual initiation and marriage (Blanc and Way 1998; Clark, Koski, and Smith-Greenaway 2017). Contraceptive use is therefore key to avoid unintended childbearing, which makes up a proportion between 50% and 90% of births to adolescent women, depending on the country (Neelofur-Khan and WHO 2007; Sedgh, Singh, and Hussain 2014). Still, most of teenage childbirths take place within marriage[3] mainly because many married adolescents want to have children. In

[3] In this article, when we refer to 'marriage' or 'married adolescents,' we include both formal marriage and consensual unions following the practice of DHS surveys, our data source.

this respect, an increasing age at marriage could be the most critical factor in postponing adolescent childbearing (ICRW 2014; UN 2013).

While unmarried adolescents have a higher unmet need for contraceptives than married women of their same age (Blanc et al. 2009; MacQuarrie 2014; UN 2014), many of them do not make use of contraceptive methods due to lack of access (Chandra-Mouli et al. 2014; Greene and Merrick 2015). This happens despite the fact that the consequences of unwanted conceptions are more severe for them: unintended childbearing, unsafe abortion, maternal and child mortality, school dropout, reduced earning potential, and lower educational achievements for the present and the next generation (Hindin et al. 2016; Neelofur-Khan and WHO 2007; Santhya and Jejeebhoy 2015; UN 2013; WHO 2010). In this respect, changing contraceptive behavior seems more achievable than changing sexual behavior in adolescents (ICRW 2014).

Unintended pregnancies to unmarried adolescents are also precipitating factors of early marriage in many societies. An indicator of this is the proportion of first births to married adolescents occurring less than eight months after marriage: The incidence of postconception marriage measured in this way among women aged 20–24 years giving birth before they are 20 years old ranges between 10% and 40% in Latin America and Africa (UN 2013). Early unions are more likely to result in the gender-based health and human rights violation of forced marriage (Banerji, Martin, and Desai 2008; UNICEF 2001, 2005; WHO 2011) and reinforce gender inequality (Raj and Boehmer 2013).

Many of the health consequences of unintended adolescent pregnancy relate to unsafe abortion (Hindin et al. 2016; Morris and Rushwan 2015; Neelofur-Khan and WHO 2007; Senanayake, Nott, and Faulkner 2001). Indeed, the prevalence of induced abortion, due to either lack of access or contraceptive failure, and the use of unsafe informal methods in termination attempts highlights the need for the continued provision of contraceptives and access to safe and affordable pregnancy termination services (Gipson and Hindin 2008; Polis et al. 2016). For this reason, the 2012 London Summit on Family Planning states the need of bringing modern contraceptive methods to women and girls recognizing the importance of family planning as a robust path to change the world (Family Planning 2020 2015), in addition to lower health costs and other social benefits (Chandra-Mouli et al. 2014; Greene and Merrick 2015). Nevertheless, despite agreement on its importance, adolescents often lack access to contraceptives, facing many barriers in acquiring contraceptives and in using them correctly and consistently (Chandra-Mouli et al. 2014). But not only lack of access to contraceptives is a problem. Many adolescents have no access to sex education leading to a lack of knowledge regarding the risks of the early sexual debut (Kirby 2011). Findings suggest that success in avoiding adolescent pregnancy often depends not only on the use of a contraceptive method but also on access to health services, education, and information (Gurr 2014). As a result, despite increasing adolescent contraceptive use, their periods of consistent use are shorter and contraceptive failures more frequent than for older women (Blanc et al. 2009; UN 2014).

Many demographers analyze the role of contraception in reducing fertility through the proximate determinants framework (Bongaarts 1978, 2015). In this framework, contraception is one of the intermediate behavioral factors influencing childbearing, the others being marriage or sexual exposure, abortion, and lactational postpartum infecundability. Standard applications of the framework take as inputs contraceptive prevalence and the contraceptive method mix, and based on published average rates of contraceptive failure impute a reduction factor of fertility due to contraception at the population or the age-specific level. Bongaarts (2017) provides an alternative method based on estimating empirically the reduction in fertility due to changes in contraceptive prevalence using fixed-effects panel regression. We follow a similar empirical approach while focusing on adolescent fertility and separating adolescents according to marital status: Earlier formulations of the proximate determinants are based on married women only. Since Stover (1998), most studies include data on all sexually active women, but all sexually active women are grouped together. This is not satisfactory for our purposes since married and sexually active unmarried adolescents have very different behavior regarding contraceptive use and demand, sexual activity, and fertility.

Despite the policy consensus on its importance, until recently not many studies have focused on adolescent contraceptive use and fewer on unmarried sexually active adolescents (Hindin and Kalamar 2017). WHO has contributed to fill that gap providing survey-specific country-sheets for 58 countries on adolescent contraceptive use that compare married adolescents and those sexually active unmarried (WHO 2016), and the DHS program has produced a monograph focusing on unmet need for young women 15–24 (MacQuarrie 2014). Loaiza and Liang (2013) and MacQuarrie (2014) show that women aged 15–19 tend to have the highest levels of unmet need for contraception and the lowest proportion of demand satisfied. Our purpose is to quantify the childbearing consequences of adolescent contraceptive use and nonuse in developing countries based on the available evidence. We first analyze contraceptive use and total demand for contraceptives of both married and unmarried adolescents and estimate the effect of such contraceptive use and total demand on fertility. In doing so, we highlight the role that increasing prevalence has had in reducing fertility and estimate the potential effect of satisfying total demand by eliminating current unmet need for contraception. This knowledge can be helpful in reaching better-informed decisions regarding SRHR policy.

2. Data and methods

2.1 Data

Demographic and Health Surveys (DHS) provide the main source of information for comparative work on adolescent contraceptive use since the 1980s (Kothari et al. 2012;

WHO 2016; Bongaarts 2017). We use aggregate information from DHS surveys carried out in developing countries between 1986 and 2015 and contained in the STATcompiler database (DHS Program 2015). We obtain data on contraceptive use, unmet need, and total demand for contraceptives of adolescent women aged 15–19, both married and sexually active unmarried women, proportions of sexually active adolescents, and adolescent fertility measured by the age-specific fertility rate ($ASFR$) 15–19 in the three years prior to the survey. In order to focus in trends over time, we restrict our analysis to countries with complete data for at least two surveys. Since almost all countries fulfilling these conditions are located in Latin America and the Caribbean (LAC) and sub-Saharan Africa (SSA) and there is insufficient or no coverage of developing countries in Asia or Northern Africa, we restrict the sample to countries in these two regions. The final sample contains 120 DHS surveys from 34 countries.[4] Table A-1 lists the included surveys together with their respective sample sizes (see Appendix). Data manipulation, estimation, and manuscript edition are carried out in R (R Core Team 2017).[5]

We first perform descriptive data analysis comparing contraceptive use and total demand of married and sexually active unmarried adolescents. Total demand for contraceptives is calculated as the sum of contraceptive prevalence and unmet need for contraception. Unmet need is defined as the share of fecund and sexually active women who have an unmet need for family planning in percentage terms. The numerator includes all pregnant women whose pregnancies are unwanted or mistimed at the time of conception; postpartum, amenorrheic women who are not using family planning and whose last birth is unwanted or mistimed; and all fecund women who are neither pregnant nor postpartum amenorrheic and who either do not want any more children (unmet need for limiting) or wish to postpone births for at least two years or do not know when or if they want another child (unmet need for spacing) but are not using any contraceptive method (UN 2014).

It would have been desirable to have separate estimates of fertility for married and sexually-active unmarried adolescents. Unfortunately, STATcompiler does not provide such data: Only the age-specific fertility rate for all women 15–19 is available. Since not all women aged 15–19 are sexually active, the conventional $ASFR$ underestimates the risk of childbearing. We have therefore adjusted for exposure based on information on time at last sexual intercourse, excluding unmarried women not having had sex in the last year.

[4] Countries included are Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Colombia, Congo, Congo D.R., Cote d'Ivoire, Dominican Republic, Ethiopia, Gabon, Ghana, Guinea, Haiti, Honduras, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Nicaragua, Nigeria, Peru, Rwanda, Sierra Leone, Tanzania, Togo, Uganda, Zambia, and Zimbabwe. Kazakhstan was the only Asian country that met our requirements but was excluded from the final sample for the reasons given in the text.

[5] `broom` (Robinson 2017) and `tidyverse` (Grolemund and Wickham 2017; Wickham 2017) for manipulation; `nlme` for estimation (Pinheiro et al. 2017); `knitr` (Xie 2014, 2015, 2017) and `texreg` (Leifeld 2013) for editing.

2.2 The model

The idea of the proximate determinants framework is to include the behavioral variables that determine fertility so that the role of socioeconomic determinants would necessarily happen through the impact in some of the proximate determinants (Bongaarts 1978). Baschieri and Hinde (2007) provide confirmation of such hypothesis in Egypt, finding that once the proximate determinants are included, the importance of socioeconomic variables in a fertility model based on microdata vanishes. Changes in the proximate determinants of fertility, such as marriage and contraceptive prevalence, should therefore provoke direct changes in fertility. The classic proximate determinants framework captures this in the equation $ASFR = C_m \times C_c \times C_a \times C_i \times AF$. For a given age-group, this equation links the potential fecundity, AF, to the actual $ASFR$ through a set of reduction factors connected to marriage, C_m; contraception, C_c; abortion, C_a; and postpartum infecundability, C_i (Bongaarts 1978; Bongaarts and Potter 1983). Stover (1998) criticizes this classic model, suggesting the use of sexual activity rather than marriage to indicate exposure, a point subsequently adopted by Bongaarts (2015). While this recognizes that not only married women contribute to fertility, it is yet simplistic for our purposes since it treats all sexually active women alike. Precisely our point is that there are differences in the proximate determinants, and specifically in the use of contraception, between married and unmarried sexually active adolescents. Figure 1 highlights the gaps in contraceptive prevalence and total demand. We therefore want to work with both groups separately.

Separating the contribution to fertility of married and unmarried women is in line with the Princeton model of fertility (Coale and Watkins 1986). This project produces joint estimates of total fertility, I_f, as a weighted average of married and unmarried fertility, I_g and I_h, using as weights the proportion married, I_m. Since the purpose is not to model the impact of contraceptive use or sexual exposure it just proposes the decomposition: $I_f = I_g \times I_m + I_h \times (1 - I_m)$.

Given our purpose to determine the effect on fertility of contraceptive prevalence for married and unmarried women separately, we need a combination of the proximate determinants and the Princeton approach. First, we classify adolescent women according to sexual exposure. The proportion of women not exposed due to lack of sexual activity (NEX) corresponds to unmarried women without sexual activity in the last year. We are therefore assuming that all married or in-union adolescents are sexually active. Exposed women are further classified into four groups based on marital status and contraceptive use. Each category is expected to have a different fertility rate according to their proximate determinants. We define the proportion of women exposed in each group as:

- MU: Proportion of married or in-union adolescent women currently using a contraceptive method among those exposed: $MU = \frac{M \cdot CPM}{1-NEX}$, where M is the proportion of married or in-union adolescents, and CPM is the proportion of married or in-union women using any contraceptive method.
- MN: Proportion of married or in-union adolescent women currently not using any contraceptive method among those exposed: $MN = \frac{M \cdot (1-CPM)}{1-NEX}$.
- UN: Proportion of sexually active unmarried adolescent women currently not using any contraceptive method among those exposed: $UN = \frac{(1-M) \cdot (1-CPU) \cdot SAU}{1-NEX}$, where CPU is the proportion of not married women not using any contraceptive method.
- UU: Proportion of sexually active unmarried adolescent women currently using any contraceptive method among those exposed: $UU = \frac{(1-M) \cdot CPU \cdot SAU}{1-NEX}$.

By definition, these four proportions add up to 1. To avoid multicollinearity, in our analysis we use the fertility of married women not using contraception as the reference category. The coefficients for the rest of proportions indicate to what extent fertility is lower when the share in these other groups increases. In the model proposed, we expect all coefficients to be negative, regardless of the country-specific averages:

$$ABRE_{it} = \beta_0 + \beta_1 MU_{it} + \beta_2 UN_{it} + \beta_3 UU_{it} + \epsilon_i + \delta_{it}, \tag{1}$$

where $ABRE_{it}$ corresponds to the adolescent birth rate among adolescent women exposed as $ABRE_{it} = \frac{ABR_{it}}{1-NEX_{it}}$.

2.3 Estimation

Our goal is to estimate the effects of contraceptive use of married and sexually active unmarried adolescents on their fertility. In doing so, we are including in our model the two main proximate determinants for adolescents, marriage or sexual exposure, and contraception. Postpartum infecundity is not that relevant for adolescents since most of the births are first births. The only main omitted factor would be abortion, since DHS surveys do not directly measure induced abortion. To the extent that abortion and other factors connected to the effectiveness of contraceptive methods do not change over time, they can be captured by a country-specific fixed or random effect. The fertility level for the reference category could then be interpreted as mean fertility after including average effects of postpartum infecundity and induced abortion, $C_a \times C_i \times AF$ in the proximate determinants terminology. Given the unbalanced panel structure of our data, we use for estimation Linear Mixed Models (LMM) with country-specific random effects (Galecki and Burzykowski 2013; Pinheiro et al. 2017). It is possible to write each observation as:

$$ABRE_{it} = \beta' X_{it} + \epsilon_i + \delta_{it}, \tag{2}$$

where $ABRE_{it}$ is our variable of interest, β the vector of coefficients, X_{it} the vector of regressors, ϵ_i the country-specific random-effect, and δ_{it} the observation-specific error term. The linear model estimate that does not take the unbalanced panel structure into account provides inconsistent variance estimates to the extent that the variance of the random-effects is different from 0. We have tested such restriction based on the exact LR test (Scheipl, Greven, and Kuechenhoff 2008) with p-values very close to zero, indicating the need to use LMM estimation.

For LMM estimation to be consistent, there should not be correlation between the random-effects and the regressors. This will not always be the case. In our specific example, for instance, we find a correlation between the random fertility effects and contraceptive prevalence: Beyond the possible causal effect of higher contraceptive prevalence on fertility, contraceptive use provides a signal of whether this is a high or low fertility country. One of the possible reasons why this could occur is a connection between the unmet need for contraception and the cultural or structural factors in the country. There are different methods to estimate consistently in the presence of such correlation, including fixed-effects estimation or the inclusion of the country-specific means of the regressors as additional covariates in an extended mixed-effects LMM model (Snijders and Berkhof 2008). We adopt the latter approach, generally called within-between or Mundlak's specification (Bell and Jones 2015; Dieleman and Templin 2014). While both methods provide identical estimates for the coefficients, the random effect specification has several advantages over fixed-effects, including the measurement of heterogeneity among countries, the possible inclusion of country-specific time-invariant covariates, or the possibility of applying the model to nations absent in the sample. It is appropriate in our case, given our focus on inference about the β coefficients. It is possible to formally test for correlation between the regressors and the random-effects with a Hausman-type test corresponding to the LR test of the general model containing the means versus the null model of regular LMM estimation. We report the results of both models. When the null of no correlation is rejected, the only consistent estimate of the causal effects is provided by the extended LMM model. When the null is not rejected at the 5% level, both estimates are consistent and our preferred model would be the regular LMM model. The preferred model in model tables is indicated by boldface, and the p-value of the Mundlak test is provided in the last row.

All the observed variables are measured with an error since they originate in a sample survey, and they are subject to sampling error. In the case of contraceptive prevalence and demand, approximate confidence intervals have been calculated based on the Wilson method (Agresti and Coull 1998) and displayed in Figure 1.[6] Measurement error also has

[6] We have used function `binconf` from the `Hmisc` R package (Harrell, Jr. and Dupont 2017). Statcompiler

potential effects on regression estimates. Note that measurement errors are correlated by design for the different variables: A sample with more unmarried women using contraceptives than in the population would likely have a lower proportion of married women and, most likely, lower fertility than the standard sample. While there are no general insights about the possible estimation bias induced (Carroll et al. 2006), it is reassuring that we would not expect sampling errors to be correlated among different countries or over time. This approach has been proven enough to eliminate bias in some particular cases (Buonaccorsi 2010: 371). Rindfuss et al. (2015) also provide empirical evidence that even when univariate distributions might be biased due to nonresponse or sampling error, regression estimates might not be affected.

Based on the preferred model and in order to interpret the policy relevance of the results, simulations of the effect on fertility rates of contraceptive prevalence are provided in the following scenarios:

- What would the levels of fertility be if contraceptive prevalence remains at the levels of the first available survey? This case indicates the effect of increasing levels of contraceptive prevalence in the sample.
- What would be the levels of fertility if total demand for contraceptives has been satisfied? Since adolescents in developing countries and, in particular, those unmarried, face high levels of unmet need, this simulation provides an idea of the potential impact of meeting total demand.

3. Results

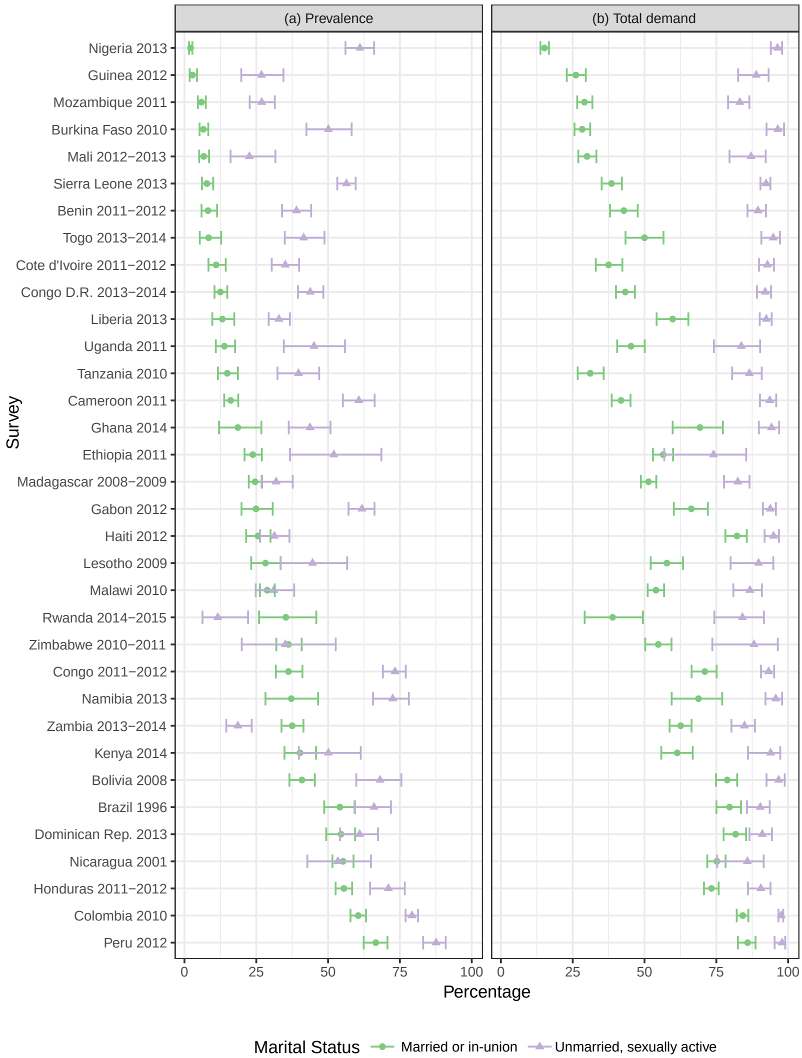
Panel (a) of Figure 1 displays the contraceptive prevalence for both sexually active unmarried and married or in-union adolescent women at the latest DHS survey. In most countries, contraceptive prevalence is higher for unmarried women, implying the importance of bringing contraceptive methods to them so that they can decide when to begin childbearing and when to get married. Thus, contraceptive prevalence for unmarried adolescents in LAC countries is 60.3% on average while in SSA countries it is lower at 38.6%.

Panel (b) of the same figure highlights even more significant differences in total demand for contraceptives. While levels of demand for married adolescents varies widely among countries, total demand for unmarried adolescents is high almost everywhere, with an average of 84.7% and 80% for LAC and SSA countries, respectively. This implies that levels of unmet need for contraception are higher for sexually active unmarried adoles-

provides the denominator for each calculation, but it does not provide the design effect or confidence intervals. The approximate confidence intervals are therefore approximations based on random sampling.

cents, indicating specific problems of access to SRHR for them. Thus, unmet need for single adolescents is 24.4% and 41.4% on average in LAC and SSA respectively.

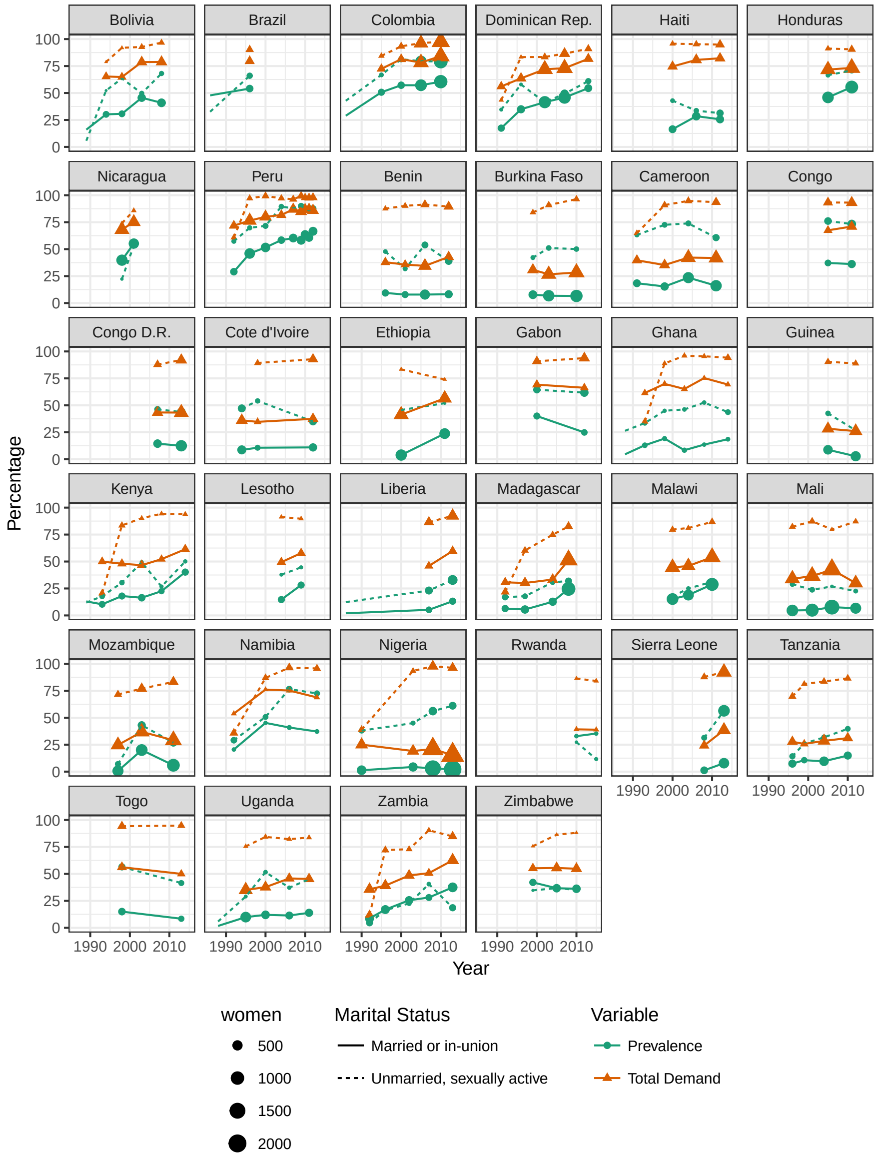
Figure 1: Contraceptive prevalence and total demand for contraceptives for adolescent women by marital status in the latest DHS survey



Note: Approximate binomial 95% intervals, Wilson method.

In most countries, contraceptive prevalence has increased over time, especially for unmarried adolescents (see Figure 2), and the pace of increase has usually been faster for unmarried adolescents. Levels of total demand have also increased for unmarried adolescents in most countries, with a less clear pattern for those married. The result of these trends is increasing differences in total demand according to marital status. While in countries like Burkina Faso, Congo D.R., Nigeria, or Zimbabwe the use of contraceptives and total demand for married adolescents have declined over time, prevalence and demand have increased for those sexually active unmarried. These results show the importance of bringing contraceptives to adolescents. However, there are a few countries where prevalence for unmarried women has declined since the first survey despite increasing or stable levels of demand (Benin, Cote d'Ivoire, Guinea, Haiti, or Togo). This indicates problems of access. In other countries, such as Burkina Faso, Cameroon, Madagascar, or Malawi, unmet need for contraceptives has also increased resulting in an increasing gap between total demand and contraceptive prevalence. Investigating the reasons behind such trends could be relevant to learn what is behind lack of access for policy purposes.

Figure 2: Trends of contraceptive prevalence and total demand for contraceptives for adolescent women by marital status



Regarding our fertility model, three different estimates appear in Table 1. The first two are LMM regressions, and the last is a linear model. The p-value of the Hausman-type test between LMM 1.1 and LMM 1.2 is 3e-04; therefore, only LMM 1.1 is consistent and the inclusion of country-specific means is necessary. It is worth noticing the change of sign of MU_{it} among LMM 1.1 and LMM 1.2, with the expected sign in LMM 1.1 once bias is corrected. This variation of the sign is in line with the explanation given above: There is a correlation between the country-specific random effects and MU_{it} since countries where the proportion married is high at adolescence are countries that have higher fertility irrespective of the causal mechanism of contraceptive use. For this reason, it is necessary to test for endogeneity and adopt a solution such as using LMM 1.1. Figure 3 maps the distribution of the random effect in the countries of our sample. It highlights that SSA countries have higher variance than LAC countries that are all more alike. An additional model is estimated, including region as a covariate. The estimated coefficient for region, 1.956, indicates slightly higher fertility in sub-Saharan Africa. However the coefficient is very close to zero as indicated by a p-value of 0.94, meaning it cannot be rejected that the coefficient is zero: The difference between SSA and LAC lies in the variance, not in the mean.

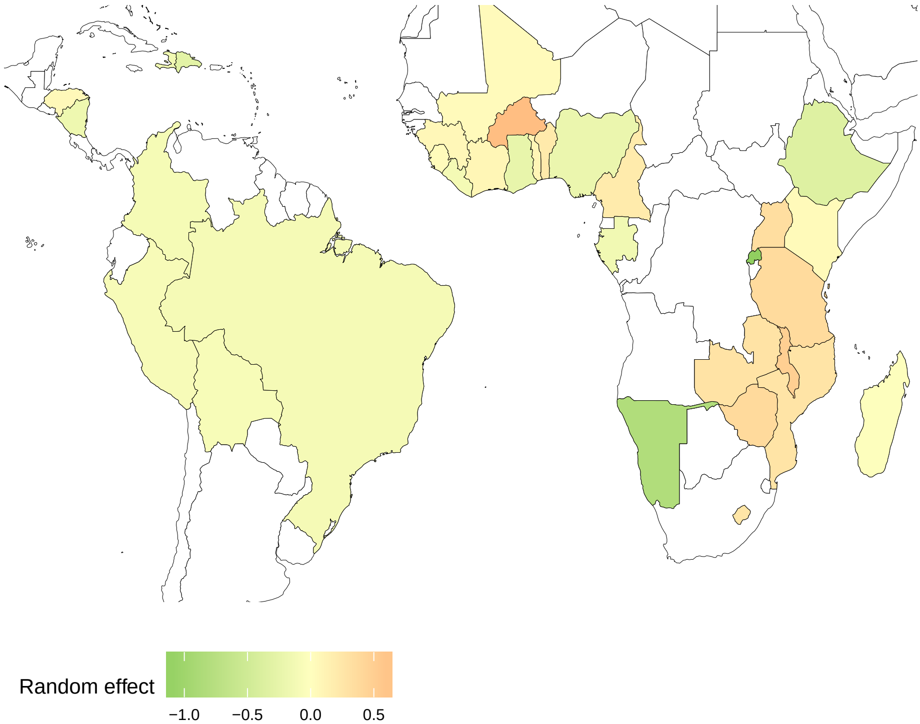
All coefficients have their expected signs in LMM 1.1, indicating that fertility is higher when the reference category, MU_{it}, is more numerous. The rest of coefficients can be interpreted as the reduction in births per thousand exposed women, occurring when shifting women from the reference category MU to a different group. The reduction connected to the use of contraception in marriage is smaller than those related to the proportions of sexually active unmarried. This indicates that the latter have a lower risk of childbearing. The marginal effect of using versus not using is also more important for sexually active unmarried adolescent women: While a switch from not using to using would imply for married adolescents a change of fertility from 0 (the reference category) to –60.6, in the case of unmarried women, the shift goes from –256 to –490.5, being 3.9 times more intense. A possible explanation is that adolescent women that marry do not mind as much or actively seek having a child.

Table 1: Model estimates for $ABRE$, adolescent birth rate for exposed women (births per thousand exposed women)

	LMM 1.1	**LMM 1.2**	**LM 1**
Intercept	342.584 ***	428.059 ***	375.367 ***
	(25.787)	(19.383)	(16.714)
MU_{it}	–60.630	125.461 *	276.064 ***
	(106.309)	(69.392)	(56.275)
UN_{it}	–256.046 ***	–192.752 ***	–109.621 ***
	(54.586)	(44.775)	(41.378)
UU_{it}	–490.514 ***	–440.670 ***	–347.411 ***
	(39.206)	(34.158)	(33.882)
$\overline{MU_i}$	382.785 ***		
	(133.793)		
$\overline{UN_i}$	181.864 **		
	(84.222)		
$\overline{UU_i}$	210.505 ***		
	(69.054)		
BIC	1,281.014	1,285.658	1,319.857
Log likelihood	–618.963	–628.466	–647.960
Num. obs.	120	120	120
sigma	34.161	35.446	54.472
sigma. RE	34.448 ***	43.182 ***	
Mundlak test (p-value)	0.000		

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Figure 3: Map of estimated random effects in model LMM 1.1



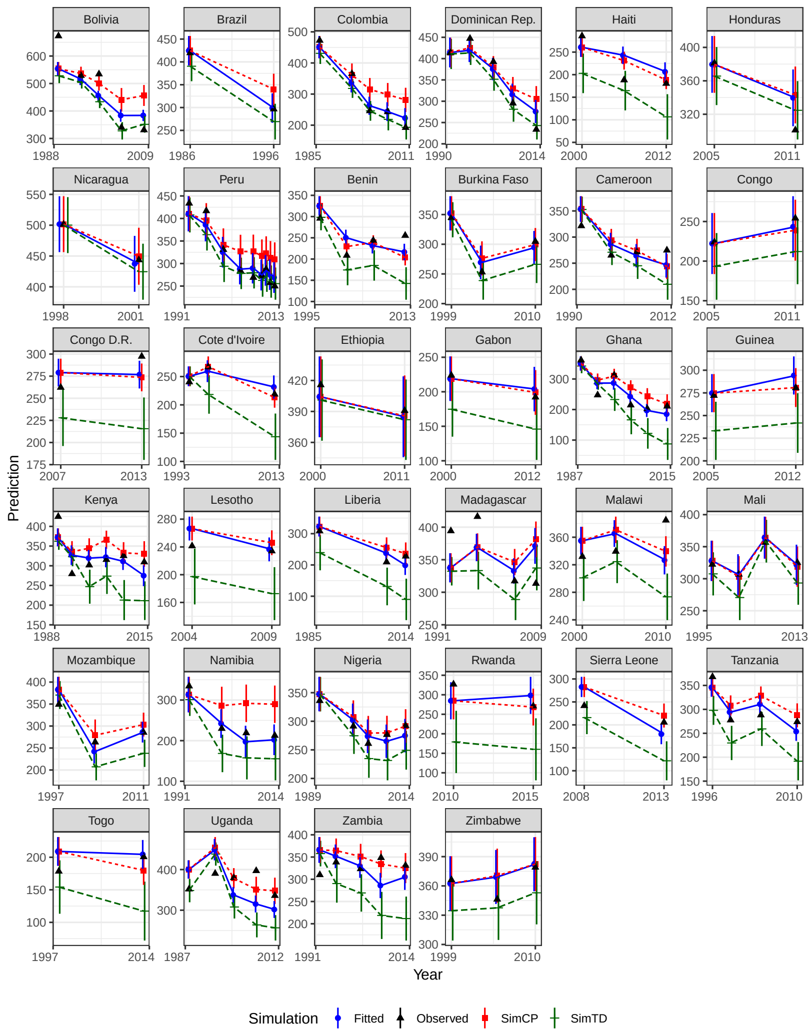
Note: Based on contraceptive prevalence and proportions of married or sexually active adolescents, positive values correspond to countries with adolescent fertility higher than expected.

To better evaluate the meaning of the previous results, we present the model fit for $ABRE$ together with the relevant simulations in Figure 4. The two simulations highlight respectively the effect that unmarried adolescent contraceptive use has already played in the reduction of adolescent fertility and its potential role if unmet need for contraception was eliminated. In the first simulation, named `SimCP`, the contraceptive prevalence for unmarried adolescents remains at the value of the first available survey. The second scenario, denoted by `SimTD`, answers the question of what would fertility be if unmet need by unmarried adolescents was eliminated with contraceptive prevalence equal to total demand.

The first most salient aspect is that model fit is quite good: The model can reproduce trends in adolescent fertility in most countries. Exceptions include Congo D.R., Madagascar, Malawi, Rwanda, Togo or Zambia. `SimCP` highlights to what extent fertility declines are due to increasing contraceptive prevalence from levels at the first available survey. In some countries like Kenya, Namibia, or Uganda, most of the fall is due to higher contraceptive prevalence. In others, like Bolivia, Brazil, Colombia, Ghana, or Peru, it makes a substantial contribution. In contrast, it has made little impact on the observed decline in countries with low contraceptive prevalence for unmarried adolescents. The average effect as a percent of observed levels in surveys after the first is 6.8% for LAC countries and 4.1% for SSA countries. The average contribution is higher in LAC where prevalence has increased faster. If contraceptive prevalence had not increased over time, $ABRE$ would be higher according to the difference between the predicted average in the `SimCP` scenario and the model fit. The average difference is 16.9 and 8 births per thousand exposed women in LAC and SSA respectively.

The second scenario, `SimTD`, highlights the potential role of meeting the demand for unmarried adolescents. Meeting total demand would have a sizable effect on adolescent fertility in almost every country. $ABRE$ would decline by 8.9% and 17.4% for LAC and SSA respectively. The higher impact in SSA is visible in Figure 4, especially for countries like Benin, Burkina Faso, Congo, Cote d'Ivoire, Gabon, Lesotho, or Tanzania. The difference between the fertility rates in the `SimTD` scenario and the model fit illustrates that meeting total demand in SSA countries would reduce fertility rates by 47.4 births per thousand exposed women on average. In the case of LAC countries, the potential effect of meeting the demand is less visible given their higher contraceptive prevalence; however, countries like Brazil, Haiti, or Honduras present higher impacts. Fertility rates would decline on average 27.2 births per thousand exposed women in LAC.

Figure 4: Adolescent birth rate for exposed women: Model fit and simulations under stalled contraceptive prevalence for unmarried adolescents (SimCP) and met total demand for unmarried adolescents (SimTD) scenarios



Note: Point estimates and 95% asymptotic confidence intervals. Comparison between scenarios should be based on differences in fitted values, and not in confidence intervals for point estimates.

At this point, we only have dealt with the effect of meeting the demand of unmarried adolescents: This has, in general, a higher impact than meeting the demand of married adolescents, given that the fertility reduction connected to their contraceptive use is larger (see Table 1). Moreover, levels of unmet need and total demand are higher for them since many married adolescents expect to have children. The contribution of meeting the total demand for married adolescents would be an additional 3.5% reduction in LAC and 2.9% reduction in SSA.

4. Discussion

Internationally agreed goals on SRHR emphasize achieving universal access to contraception, and our analysis corroborates that a focused perspective is needed so adolescents, and in particular those unmarried sexually active, are not left aside in global monitoring. The situation of lack of access is particularly intense for them: A vast majority of unmarried sexually active adolescents have a demand for family planning, which is larger than demand by married adolescents. Levels of unmet need are also larger for those unmarried sexually active.

Through the simulations, it is possible to infer the two sides of the problem at the same time: There would have been higher adolescent fertility if contraceptive use had not increased over time, and there is still a strong potential reduction of adolescent fertility by satisfying current demand levels. Our analysis shows that increasing levels of contraceptive use by sexually active unmarried adolescents play an important role in explaining the reductions observed in adolescent fertility in many countries. While meeting the demand for family planning of both married and unmarried adolescents reduces adolescent fertility, the impact of meeting the demand is higher for the latter. These effects are sizable: Meeting the demand of both groups would decrease fertility by a 12.4% in LAC and 20.3% in SSA. There is a substantial literature on the negative consequences of adolescent pregnancy and childbearing regarding maternal and child mortality, unintended pregnancy, unsafe abortion, educational dropout, and lower incomes (Hindin et al. 2016; Neelofur-Khan and WHO 2007; Santhya and Jejeebhoy 2015; UN 2013; WHO 2010). In this context, lowering the incidence of adolescent pregnancy by satisfying current demand levels could avoid many of these adverse outcomes and the subsequent reduction of well-being for this and the next generation. Strengthening health systems to meet the needs and priorities of unmarried adolescents should, therefore, be a priority.

While we have focused on the impact of increasing contraceptive prevalence, the literature indicates the importance not only of use but also of effective use. In this respect, sex education and the adoption of more efficient methods could play an important additional role. Sex education leads to increasing demand for contraceptives (Kirby 2011; Gurr 2014), but if women do not have access to them, it results in higher rates of unmet need. We estimated through `SimTD` the potential reduction in fertility of satisfying unmet need. Furthermore, some findings show that adolescents are less likely to change their patterns of sexual activity than their contraceptive practice (ICRW 2014). Meeting their contraceptive needs can, therefore, avoid unintended pregnancies and unsafe abortions.

The effect on fertility of increasing contraceptive use is larger for unmarried women than for married women signaling that the former are not willing yet to begin childbearing. Indeed, our estimations show a higher impact of contraceptive use on fertility, in the order of almost four to one, in the case of sexually active unmarried women.

Standard demographic models, such as the proximate determinants framework and the Princeton model, are, from the perspective of this research, too simple. The sharp differences in behavior among adolescents according to marital status indicate the need to analyze them separately. We have done this by broadening the proximate determinants framework in the spirit of the Princeton model while making explicit the role of contraceptive use and controlling for sexual exposure. Due to the significant adverse consequences of adolescent childbearing in countries with high rates, such as most of SSA and LAC, it is key not to leave any group aside – in particular, those unmarried sexually active. Our results on the importance of contraceptive prevalence are in line with the imputed reductions based on contraceptive prevalence in applications of the demographic determinants framework (Bongaarts and Potter 1983; Bongaarts 2015). The difference is that we are estimating the effect instead of imputing it, a similar approach to Bongaarts (2017). In that paper it is argued, based on fixed-effects regressions, that the impact of contraceptive prevalence on fertility is not different in sub-Saharan Africa to other regions. This is in line with our findings, but we have found a large heterogeneity in the estimated random-effects in SSA that is not found in LAC. This suggests that there are other factors at play in the African case beyond contraceptive prevalence. Singh, Bankole, and Darroch (2017) look at the impact of contraceptive prevalence on fertility in SSA by means of similar scenarios to the ones devised in this paper using a proximate-determinants like accounting framework. They find that fertility would increase 35% in SSA if contraceptive prevalence were set to zero and that satisfying current unmet need for modern methods would further reduce fertility by an average of 22% for all women aged 15–49. Our estimates for adolescents aged 15–49 are of comparable magnitude based on a different approach.

Regarding the limitations of our study, we have not explicitly addressed the effectiveness of contraceptive methods used by adolescents. Using more efficient methods in combination with condom use for the prevention of sexually transmitted diseases would imply a higher public health impact. There is also no information on induced abortion, which would have made the estimates more robust.

We have carried out the analysis based on aggregate survey data. While this is enough to hint at the potential impact of meeting contraceptive needs of adolescents, the use of individual data including contraceptive calendar data would allow for a finer control and measurement of the fertility reduction effect of contraceptive use for the different groups of women in different countries. However, not all surveys report information for unmarried women. In this regard, and for our current purposes, it is enough to use aggregate data. Nevertheless, we intend to use individual-level data in future research to more precisely estimate differences in fertility according to marital status and contraceptive use. This can also avoid some of the shortcomings of aggregate indicators, replacing them for more accurate ones. One such case is the measurement of the proportion sexually active. The standard definition of sexual activity is based on intercourse in the last four weeks; nonetheless, this is not the relevant concept from the perspective of fertility, in which a more prolonged period would be desirable, in particular for unmarried women (we consider all married adolescents are exposed). Singh, Bankole, and Darroch (2017) extend it to three months. Our operational definition is based on sexual exposure in the last year, assuming that patterns of contraceptive prevalence are similar than for those sexually active in the previous four weeks.

An additional concern regards data availability. Many countries are still not reporting on demand for contraceptives, sexual activity, and other SRH dimensions for unmarried adolescents, as is the case of many Asian countries. Lack of data makes the adoption of well-informed policy decisions more difficult, and it might mean that special needs such as those of sexually active unmarried adolescents are not addressed.

5. Acknowledgments

An earlier version of this research was presented at the 2017 IUSSP XXVIII International Population Conference in Cape Town, South Africa. David Sánchez-Páez acknowledges a travel grant from the University of Salamanca, and José Antonio Ortega the support from the Junta de Castilla y León (research grant SA072U16). The authors wish to thank the two anonymous referees for their valuable comments and suggestions.

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Appendix

Table A-1: DHS surveys included in the analysis

Country	Year	Sample size (women) All ages	15–19
Latin America and the Caribbean			
Bolivia	1989	7,923	1,682
Bolivia	1994	8,604	1,805
Bolivia	1998	11,187	2,497
Bolivia	2003	17,654	3,874
Bolivia	2008	16,938	3,518
Brazil	1986	5,892	1,305
Brazil	1996	12,614	2,464
Colombia	1986	5,332	1,208
Colombia	1995	11,141	2,166
Colombia	2000	11,586	2,264
Colombia	2005	38,355	6,902
Colombia	2010	49,818	9,100
Dominican Rep.	1991	7,320	1,711
Dominican Rep.	1996	8,421	1,801
Dominican Rep.	2002	23,384	4,550
Dominican Rep.	2007	27,195	5,580
Dominican Rep.	2013	9,372	1,820
Haiti	2000	10,158	2,342
Haiti	2006	10,758	2,701
Haiti	2012	14,287	3,352
Honduras	2005	19,948	4,510
Honduras	2011	22,757	5,062
Nicaragua	1998	13,635	3,307
Nicaragua	2001	13,059	3,141
Peru	1992	15,882	3,477
Peru	1996	28,950	6,138
Peru	2000	27,843	5,645
Peru	2004	17,519	3,346
Peru	2007	23,034	4,208
Peru	2009	24,212	4,536
Peru	2010	22,948	4,279
Peru	2011	22,518	4,118
Peru	2012	23,888	4,423
Sub-Saharan Africa			
Benin	1996	5,492	1,075
Benin	2001	6,219	1,233
Benin	2006	17,793	3,067
Benin	2012	16,600	2,907
Burkina Faso	1999	6,446	1,444
Burkina Faso	2003	12,477	2,776
Burkina Faso	2010	17,087	3,312
Cameroon	1991	3,871	919
Cameroon	1998	5,502	1,282
Cameroon	2004	10,656	2,684
Cameroon	2011	15,426	3,589

Table A-1: (Continued)

Country	Year	Sample size (women) All ages	15–19
Sub-Saharan Africa			
Congo D.R.	2007	9,995	2,030
Congo D.R.	2013	18,826	4,054
Congo Rep.	2005	7,052	1,566
Congo Rep.	2011	10,820	2,198
Cote d'Ivoire	1994	8,098	1,961
Cote d'Ivoire	1998	3,039	775
Cote d'Ivoire	2012	10,059	2,023
Ethiopia	2000	15,368	3,710
Ethiopia	2011	16,514	4,009
Gabon	2000	6,182	1,587
Gabon	2012	8,423	1,784
Ghana	1988	4,488	849
Ghana	1993	4,562	803
Ghana	1998	4,843	910
Ghana	2003	5,691	1,148
Ghana	2008	4,916	1,025
Ghana	2014	9,396	1,625
Guinea	2005	7,954	1,648
Guinea	2012	9,143	2,023
Kenya	1989	7,150	1,497
Kenya	1993	7,541	1,754
Kenya	1998	7,881	1,851
Kenya	2003	8,195	1,856
Kenya	2008	8,445	1,761
Kenya	2014	31,080	5,820
Lesotho	2004	7,094	1,710
Lesotho	2009	7,624	1,785
Liberia	1986	5,239	1,137
Liberia	2007	7,092	1,312
Liberia	2013	9,239	2,080
Madagascar	1992	6,261	1,420
Madagascar	1997	7,059	1,553
Madagascar	2004	7,948	1,528
Madagascar	2008	17,374	3,956
Malawi	2000	13,219	2,867
Malawi	2004	11,698	2,392
Malawi	2010	23,020	5,005
Mali	1996	9,703	1,883
Mali	2001	12,849	2,565
Mali	2006	14,583	3,104
Mali	2012	10,425	1,891
Mozambique	1997	8,778	1,836
Mozambique	2003	12,417	2,454
Mozambique	2011	13,745	3,061
Namibia	1992	5,422	1,259
Namibia	2000	6,754	1,499
Namibia	2006	9,803	2,246
Namibia	2013	9,176	1,906

Table A-1: (Continued)

Country	Year	Sample size (women) All ages	15–19
Sub-Saharan Africa			
Nigeria	1990	8,780	1,612
Nigeria	1999	8,205	1,775
Nigeria	2003	7,620	1,716
Nigeria	2008	33,385	6,493
Nigeria	2013	38,949	7,820
Rwanda	2010	13,671	2,945
Rwanda	2015	13,497	2,768
Sierra Leone	2008	7,373	1,198
Sierra Leone	2013	16,657	3,878
Tanzania	1996	8,119	1,732
Tanzania	1999	4,029	909
Tanzania	2004	10,329	2,245
Tanzania	2010	10,139	2,172
Togo	1998	8,570	1,787
Togo	2013	9,481	1,700
Uganda	1988	4,729	1,157
Uganda	1995	7,069	1,606
Uganda	2000	7,246	1,615
Uganda	2006	8,531	1,936
Uganda	2011	8,674	2,048
Zambia	1992	7,060	1,984
Zambia	1996	8,020	2,003
Zambia	2002	7,657	1,811
Zambia	2007	7,146	1,574
Zambia	2013	16,410	3,625
Zimbabwe	1999	5,907	1,447
Zimbabwe	2005	8,908	2,152
Zimbabwe	2010	9,171	1,945