Annex 28A. Estimation Methods Used in the Extended Cost-Effectiveness Analysis of Postponing Adolescent Parity

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1. Linear relationship between increases in female education levels and adolescent pregnancy rate

We examined the relationship between mean years of education among women aged 15-44 (denoted Edu) [1] and adolescent (15-19 year-olds) pregnancy rate (denoted TP) (percentage of women aged 15-19 who have had children or are currently pregnant), in a given low- and middle-income country [2], controlling for gross domestic product per capita ($GDPc$) and additional variables (Table 28A.1), using the following type of linear model:

$$\ln(TP) = \alpha_0 + \alpha_1 Edu + \alpha_2 \ln(GDPc) + \varepsilon \, .$$

The additional variables controlled for (Table 28A.1) were so selected because they were readily available for low- and middle-income countries from the World Bank Development Indicators database [2]. The complete results of the linear models tried are given in Table 28A.1. For our analysis we retained model (4) where $\alpha_1 = -0.18$. This meant that an increase by 1 year of the mean number of years of education among women aged 15-44 would lead to a relative decrease of the adolescent pregnancy rate of 18% in a given country.

2. Estimation of adolescent maternal mortality and impoverishment

This section describes the methods we used for the estimation of adolescent maternal mortality and impoverishment. Specifically, we estimated the level and distribution (across income quintiles) of: (1) the number of adolescent maternal deaths; (2) the out-of-pocket (OOP) expenditure; and (3) the number of cases of catastrophic health expenditure incurred.
In a given country, we divided the population in five income groups J and we defined: y, the income of an individual, and $f(y)$, the income distribution; p_J the probability of complicated delivery conducted with skilled birth attendance; and c_J the associated costs borne out of pocket by the woman. Increased educational attainment had an impact denoted Eff. All the symbols used are listed and defined in Table 28A.2.

Table 28A.1. Least Squares Regression of the Logarithm of Teenage Pregnancy Rate (Percentage of Women aged 15-19 who have had Children or are Currently Pregnant) in Low- and Middle-Income Countries

	(1)		(2)		(3)		(4)	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Mean years of education among 15-44 year-old women	-0.11***	0.02	-0.11***	0.02	-0.15***	0.02	-0.18***	0.02
Logarithm of per capita GDP	0.00	0.05	0.02	0.06	0.02	0.08	0.17*	0.10
Percent of rural population			0.00	0.00	-0.00	0.00	0.00	0.00
Percent of households with female head					0.01	0.00	0.01*	0.01
Percent of women in parliament							-0.01	0.01
Constant	3.43***	0.31	3.26***	0.52	3.55***	0.66	2.57***	0.86
Number of observations	216		216		147		98	
R^2	0.30		0.30		0.42		0.48	

Note: data are from the World Bank database, http://data.worldbank.org/, and the Institute of Health Metrics and Evaluation, http://ghdx.healthdata.org/ihme_data. Years 1970-2009 are included. The following low- and middle-income countries are included: Armenia, Azerbaijan, Burundi, Benin, Burkina Faso, Bangladesh, Bolivia, Botswana, Côte d'Ivoire, Cameroon, Congo, Colombia, Dominican Republic, Ecuador, Egypt, Ethiopia, Georgia, Ghana, Guinea, Guatemala, Honduras, Indonesia, India, Jamaica, Jordan, Kazakhstan, Kyrgyzstan, Cambodia, Laos, Liberia, Sri Lanka, Lesotho, Morocco, Moldova, Madagascar, Mali, Mozambique, Mauritania, Malawi, Namibia, Niger, Nigeria, Nicaragua, Nepal, Pakistan, Peru, Philippines, Paraguay, Romania, Rwanda, Senegal, Sierra Leone, El Salvador, Swaziland, Chad, Togo, Tajikistan, Tunisia, Turkey, Tanzania, Uganda, Ukraine, Vietnam, South Africa, Democratic Republic of the Congo, Zambia, Zimbabwe. Outcome variable is the percentage of women ages 15-19 who have had children or are currently pregnant. Standard errors are heteroskedasticity-robust. Coefficients which are statistically significant at 10%, 5%, and 1% level are marked with *, **, and *** respectively. GDP = gross domestic product (current US$); Coeff. = regression coefficient; SE = standard error.

Note that the number of observations retained in this analysis corresponds to the total number of country-years available in the World Bank databases (http://data.worldbank.org).

Table 28A.2. Symbols Used in the Modeling and Corresponding Definitions

Symbol	Definition
y	Individual income
$f(y)$	Income distribution as a function of individual income
p_J	Probability of a complicated delivery conducted with skilled birth attendance in income quintile J
c_J	Out-of pocket costs for a complicated delivery conducted with skilled birth attendance in income quintile J
Eff	Impact of increased education on reducing teenage pregnancy rate
AP_J	Distribution of pregnancy rate among adolescents in income quintile J
RR	Relative risk of increased maternal mortality for adolescents (ages 15-19) as compared with older age groups
μ_{Total}	Maternal mortality ratio (per 100,000 live births)
Ado	Number of adolescent women aged 15-19
D_J	Total maternal deaths in income quintile J
PE_J	Adolescent women expenditure in income quintile J
CHE_J	Catastrophic health expenditure in income quintile J

2.1. Maternal deaths

We estimated the number of maternal deaths over one year in a given country, using notably the relative mortality RR for adolescent pregnancy as compared with older age groups (20-24 year-olds) and the distribution of adolescent pregnancies per income quintile (AP_J). By income quintile J, the maternal deaths were estimated as:

$$D_J = \frac{1}{5} * \ AP_J * RR * \ \mu_{Total} * Ado \ ,$$

where μ_{Total} was the maternal mortality ratio in the country before the policy, and Ado was the total number of adolescent women aged 15-19 in the country. Subsequently, using Eff, we could estimate the number of maternal deaths averted through increased education attainment.

2.2. Out-of-pocket costs

We estimated the adolescent women expenses[1] in a given country. For the income quintile J (per capita), the expected out-of-pocket costs were:

$$PE_J = \frac{1}{5} * \ p_J * \ c_J * AP_J * Ado \ ,$$

where p_J was the probability of visit for complicated delivery conducted with skilled birth attendance, and c_J were the associated OOP costs. Subsequently, using Eff, we could estimate the amount of out-of-pocket costs averted through increased educational attainment.

2.3. Catastrophic health expenditure

Per income quintile, we estimated the number of cases of catastrophic health expenditure caused by complicated maternal deliveries. To do so, we counted the number of adolescent women whose out-of-pocket expenses c_J were larger than $0.10 * y$ (where we recall y is the individual's income). For this purpose, we used an income distribution f based on a gamma density based on country gross domestic product (GDP) per capita and Gini index [2-4]. Subsequently, using Eff, we estimated the number of those cases of catastrophic expenditure that would be averted by increased educational attainment.

3. Sensitivity analysis

We pursued univariate sensitivity analyses where: (1) different thresholds (20 percent and 40 percent) for the catastrophic health expenditure were used (Tables 28A.3 and 28A.4); (2) a poverty headcount (individuals crossing the country poverty line due to out-of-pocket costs) in lieu of catastrophic health expenditure was used (Tables 28A.3 and 28A.4); and (3) a different size (smaller 11% relative reduction instead of 18 percent, as given in Table 28A.1) for the impact of increased female education on the adolescent pregnancy rate was used (Tables 28A.5 and 28A.6).

[1] In this analysis, only direct medical costs and transportation costs disbursed out of pocket were included.

Table 28A.3. Adolescent impoverishment induced in Niger, using a variety of metrics: cases of catastrophic health expenditure with a threshold of 10 percent (base case); cases of catastrophic health expenditure with a threshold of 20 percent; cases of catastrophic health expenditure with a threshold of 40 percent; and poverty cases using the national poverty line ($316 annual).

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Catastrophic health expenditure, 10% threshold	1,110	130	200	200	240	330
Catastrophic health expenditure, 20% threshold	960	130	200	200	240	180
Catastrophic health costs, 40% threshold	410	130	210	70	0	0
Poverty cases	210	0	0	110	100	0

Note: 95 percent uncertainty ranges in parentheses.

Table 28A.4. Adolescent impoverishment induced in India, using a variety of metrics: cases of catastrophic health expenditure with a threshold of 10 percent (base case); cases of catastrophic health expenditure with a threshold of 20 percent; cases of catastrophic health expenditure with a threshold of 40 percent; and poverty cases using the national poverty line ($787 annual).

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Catastrophic health expenditure, 10% threshold	1,250	400	360	260	170	70
Catastrophic health expenditure, 20% threshold	1,280	1,280	0	0	0	0
Catastrophic health expenditure, 40% threshold	270	270	0	0	0	0
Poverty cases	2,080	0	2,080	0	0	0

Note: 95% uncertainty ranges in parentheses.

Table 28A.5. Impact of increasing mean years of female education by 1 year in Niger (with a smaller impact of 11 percent relative reduction in lieu of 18 percent): number of adolescent maternal deaths averted, amount of adolescent out-of-pocket costs averted, and number of adolescent catastrophic health expenditure averted, per income quintile.

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Maternal deaths averted	100	25	25	20	20	10
Out-of-pocket costs averted (1000s of 2014 US$)	93	8	16	18	19	32
Cases of catastrophic health expenditure averted	680	80	120	120	150	200

Note: 95% uncertainty ranges in parentheses.

Table 26A.6. Impact of increasing mean years of female education by 1 year in India (with a smaller impact of 11 percent relative reduction in lieu of 18 percent): number of adolescent maternal deaths averted, amount of adolescent out-of-pocket costs averted, and number of adolescent catastrophic health expenditure averted, per income quintile.

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Maternal deaths averted	760	240	220	160	100	40
Out-of-pocket costs averted (1000s of 2014 US$)	1860	260	370	450	460	330
Cases of catastrophic health expenditure averted	3190	3190	0	0	0	0

Note: 95% uncertainty ranges in parentheses.

References

1. Institute for Health Metrics and Evaluation (IHME). 2010. *Educational Attainment and Child Mortality Estimates by Country 1970-2009*. Institute for Health Metrics and Evaluation: Seattle.

2. World Bank. 2015. *World Development Indicators 2015*. Washington, DC: World Bank.

3. Salem, A.B.Z. and T.D. Mount. 1974. "Convenient Descriptive Model of Income Distribution: The Gamma Density." *Econometrica*. 42(6):1115-1127.

4. Kemp-Benedict E. 2001. "Income Distribution and Poverty – Methods for using Available Data in Global Analysis. Available from: http://gdrs.sourceforge.net/docs/PoleStar_TechNote_4.pdf (accessed November 10, 2015).