Age at first birth and fertility: Global variation in proximate causes

Kermyt G. Anderson[1] and Leah Tanner[2]

1. Department of Anthropology, University of Oklahoma, USA kganders@ou.edu

2. Bloomberg School of Public Health, Johns Hopkins University, USA ltanner8@jhmi.edu

Prepared for the 2019 Annual Meeting of the Population Association of America.

Introduction

In recent decades, total fertility rate (TFR), a synthetic measure of births per woman, has dropped dramatically across every global region. With the exception of Africa, whose fertility remains high, all other regions are converging on or near replacement (TFR $\leq$ 2.1) (Lam 2011; Morgan and Taylor 2006; van Bavel 2013). Many factors are associated with reduced TFR, including education (especially women's), wealth, labor force participation, taxes, and increased costs of children (Colleran and Snopkowski 2018; Lam 2011; Manuelli and Seshadri 2009; Morgan 2003), though debate surrounds the mechanisms responsible for this demographic transition (e.g., Lam 2011; Morgan and Taylor 2006).

Frameworks for proximate determinants of fertility focus on factors influencing exposure to intercourse, conception, and parturition (Bongaarts 1978, 2015; Morgan and Taylor 2006; Wood 1994). Globally, contraceptive usage has increased greatly in recent decades (Cleland 2009; Tsui et al. 2017). However, there is debate about whether contraceptive availability determines demand for children or vice versa (Lam 2011). I.e., is contraceptive usage a driving force in global fertility reduction, or does it merely reflect a proximate pathway to reduced fertility that is driven by reduced demand for children in emerging market economies?

This paper focuses on one particular aspect of the proximate determinants of fertility, namely the relationship between global fertility patterns and contraception usage. In particular, the paper

examines the relationship between age at first birth (AFB) and fertility. While the global decrease in fertility is well documented, little work has examined its association with age at first birth. All else being equal, delayed age at first birth will decrease TFR (Anderson and Low 2003; Morgan and Taylor 2006). Delayed AFB can be achieved through abstinence (including delayed age at first sex or marriage) or through contraception (Bongaarts 1978, 2015; Wood 1994). However, delayed AFB may be compensated for by reduced interbirth intervals or delayed age at last birth, resulting in no change in TFR. This leads to two predictions to be tested in this study:

Prediction 1: Age at first birth is negatively associated with fertility.

Prediction 2: Contraceptive usage is positively associated with age at first birth and negatively associated with fertility.

Methods

The study will use cross-sectional data on age at first birth, fertility, and contraception for 157 countries from 2001 through 2014. Age at first birth comes from the 2012 World Fertility Report (United Nations 2013). Fertility is measured through three variables: total fertility rate (TFR), representing lifetime completed fertility, and two measures of age-specific fertility rate: ASFR 20-24, measuring fertility early in the reproductive life course (ages 20-24), and ASFR 35-39, measuring fertility late in the reproductive course (ages 35-39). TFR is measured as number of children per woman, while the ASFR variables are measured as number of births per 1,000 women per year in each respective five-year interval. These fertility measures are from the from the World Fertility Data file, and come from censuses, household surveys or national estimates provided by statistical offices and cross-national survey programs (United Nations 2017b).

Data on contraceptive use were extracted from the World Contraceptive Use file (United Nations 2017a), using the most recent year available (2001-2014; median 2010) for 158 countries. Two measures of contraceptive usage are used. *Modern contraception* includes female sterilization, male sterilization, IUD, implant, injectable, pill, male condom, female condom, vaginal barrier methods, and emergency contraception. *Traditional contraception* includes the rhythm method, withdrawal, and other traditional methods. Both variables measure the percentage of respondents who use those respective methods. Measures of contraceptive usage come from survey data; see United Nations (2017a) for specific details. Other variables (population size, per capita Gross National Income) come from the *CIA World Factbook* (2017) and the Population Reference Bureau's *World Population Datasheet* for the closest year to the most recent year that contraceptive data is available for each country (e.g., Population Reference Bureau 2017).

Analysis

Means are weighted by national population size. Non-parametric spearman correlations are used due to the nonlinear relationship between some variables. Countries are grouped into six regions: Africa, Asia, Europe, Latin America, North America and the Caribbean, and Oceania. Each region is further subdivided into between two and five subregions (22 subregions in total). Multivariate analysis is done using multilevel mixed-effects generalized linear models (mmglm), which adjust for hierarchical grouping of nations at the level of the region and subregion. All models control for logged per capita gross national income. Analyses were done using Stata v. 14.1.

Results

Table 1 presented descriptive statistics for age at first birth, fertility, and contraceptive usage, by region. There is tremendous regional variation for each measure. AFB is lowest in Africa, Asia and Latin America, and highest in North America/Caribbean, Europe, and Oceania. TFR is roughly twice as high in Africa as each of the other regions, with Europe having the lowest fertility. Prevalence of modern contraception is highest In North America/Caribbean and Latin America, and lowest (less than half of other regions) in Africa. Traditional contraception, in contrast, is lowest in Oceania, and highest in Europe. (Further analysis [not shown] reveals that the high prevalence of traditional contraception in Europe is driven by the high usage of withdrawal in southern and eastern Europe.)

[Table 1 about here]

Specific forms of contraception vary greatly by region (Table 2). Modern and traditional methods are listed separately, and presented in reverse order of global prevalence (i.e., female sterilization is the most prevalent modern method, and male sterilization the least). Within each region, the three most prevalent methods are in bold. Note that no single contraceptive method is among the top three methods for every region, though the pill and the male condom are in the top three for five of the six regions. Although female sterilization is the most prevalent method globally, it is fairly rare in Africa, Europe, and Oceania. Injectable contraception is a top three method only in Africa, while male sterilization is a top three method only in Oceania.

[Table 2 about here]

Spearman correlation coefficients between age at first birth, fertility, and contraception prevalence are presented in Table 3. All correlations are significant at $p < 0.01$, except for the correlation between traditional and modern contraception which is not significant ($p = 0.16$). Consistent with prediction 1, AFB is negatively correlated with total fertility, early fertility (ASFR 20-24), and late fertility (ASFR 35-39). Consistent with prediction 2, AFB is positively correlated with both measures of

contraception usage, and both measures of contraception are negatively correlated with all three measures of fertility. Note that the correlation coefficients between fertility and modern contraception prevalence are higher than those between fertility and traditional contraception, perhaps reflecting the greater effectiveness of modern versus traditional contraception.

[Table 3 about here]

Regional relationships between age at first birth, total fertility rate, and contraception usage are presented visually in Figures 1 to 3. Figure 1 plots TFR by AFB, by region. The relationship is negative and significant for Africa (Spearman rho = -0.5019, p = 0.0007) and Asia (Spearman rho = -0.5174, p = 0.0040). Figure 2 plots TFR against the prevalence of both modern and traditional contraception, by region. The relationship between modern contraception and TFR is significant and negative in Africa (Spearman rho = -0.6159, p < 0.0001), Asia (Spearman rho = -0.5511, p = 0.0003), and Latin America (Spearman rho = -0.6986, p = 0.0026). Traditional contraception is not negatively associated with TFR in any region, and is positively associated with TFR in Latin America (Spearman rho = 0.5380, p = 0.0316). Lastly, Figure 3 plots AFB against contraception prevalence, by region. Modern contraception usage is unrelated to age at first birth for any region, exception Europe (Spearman rho = 0.6485, p = 0.0005). Traditional contraception usage is unrelated to AFB for all regions except Europe (Spearman rho = -0.5890, p = 0.0025).

[Figures 1, 2 and 3 about here]

Table 4 presents mixed-effects glm models predicting AFB and fertility by contraception usage. Neither modern nor traditional contraceptive use predicts AFB (though traditional contraception is marginally significant at p = 0.065). Both modern and traditional contraception are significantly negative predictors of TFR, ASFR 20-24, and ASFR 35-39.

[Table 4 about here]

Table 5 presents mixed-effects glm models of fertility measures predicted by both AFB and contraception. Age at first birth is not a significant predictor of TFR or late fertility (ASFR 35-39), though it negatively predicts early fertility (ASFR 20-24). Both modern and traditional contraception are associated with reduced levels of total, early, and late fertility.

[Table 5 about here]

When run separately by region (only for regions with n>11, i.e. excluding North America/Caribbean and Oceania), AFB predicts reduced TFR only in Africa, and is non-significant for Asia, Europe, and Latin America (Table 6). AFB predicts reduced early fertility (ASFR 20-24) for Africa, Europe, and Latin America, but is non-significant for Asia, while AFB is not a significant predictor of late fertility (ASFR 35-39) for any region. Modern contraception predicts reduced TFR for Africa, Asia and Latin America but not Europe, while traditional contraception predicts reduced fertility only for Asia and is non-significant for other regions. Early fertility (ASFR 20-24) is negatively predicted by modern contraception usage only in Asia and Latin America, while traditional contraception does not predict early fertility for any region. Late fertility (ASFR 35-39) is negatively predicted by modern contraceptive prevalence in Africa, Asia and Latin America, while traditional contraception successfully predicts reduced late fertility only in Asia. Traditional contraception also predicts higher late fertility in Latin America.

[Table 6 about here]

Discussion

This paper used cross-sectional data on 157 countries to examine the relationships between age at first birth, fertility, and contraception usage. There is tremendous regional variation in contraceptive

usage, with no single method predominate in every region. Also, while modern contraception is more widely used than traditional contraception, traditional contraception was nonetheless widespread. At least one traditional method (withdrawal or the rhythm method) was more common than at least one of the six most commonly used modern methods (Table 2). Modern and traditional contraception usage are not correlated (Table 3), suggesting they are not substituting for each other.

The paper tested two predictions. Prediction 1, that age at first birth is negatively associated with fertility, received mixed support. Controlling for income and contraceptive usage, age at first birth is negatively associated only with early fertility, but does not predict late fertility or total fertility. When examined by region, age at first birth is negatively associated with early fertility in Africa, Europe and Latin America, but does not predict late fertility in any region, and is associated with total fertility in Africa only. Since AFB does not predict TFR in most global regions, this suggests that global TFR reduction may be a result of increased birth spacing or earlier age at last birth rather than delayed first birth. Unfortunately those variables are not readily available in a comparative cross-national sample.

The second prediction posited that contraceptive usage is positively associated with age at first birth and negatively associated with fertility. Neither modern nor traditional contraceptive usage is associated with AFB when income is controlled for. Regionally, the relationship between contraception and AFB varies (Figure 3), but is not significant in multilevel mixed-effects generalized linear models for any region (not shown). Contraceptive usage is associated with fertility in most regions. Modern contraception predicts lower total fertility in Africa, Asia, and Latin America, lower early fertility in Asian and Latin America, and lower late fertility in Africa, Asia, and Latin America. Traditional contraception has a weaker relationship with fertility; it predicts lower total fertility and late fertility in Asia, and higher late fertility in Latin America, while traditional contraception is not related to early fertility in any region. Notably, neither measure of contraception usage is associated with any fertility variable in Europe (Table 6; see also Figure 2). This begs the question: how does Europe maintain the lowest fertility in the

world, as shown in Table 1? Europe exhibits very little variance in fertility, and it appears that, regardless of age at first birth (Figure 1) or contraceptive usage (Figure 2), nearly every European nation has similar fertility. If birth spacing or age at last birth is a factor in Europe's low fertility, how is this achieved without contraception? One possibility may be elective abortion, though abortion data are limited. Preliminary analysis (not shown) found no association between abortion rate (n = 51 countries; data from Singh et al. 2018), either globally or by region.

A few limitations of the study should be noted. The data are cross-sectional, using the most recent year for which U.N. contraceptive data was available, and matching this to the same year (or the nearest one within three years) in the U.N. fertility dataset. We cannot infer causation using this dataset. In particular, variables such as modern contraception may be proxies for other factors, such as accessibility of health care or the quality of the medical system. However, we have controlled for per capita income, which partially accounts for cross-national variance in income. Other variables, including GINI coefficient and literacy rate, were used in exploratory analysis, but it was found the models were overspecified, and income was retained as it had the largest sample size as well as the greatest theoretical importance.

In conclusion, this study has found that age at first birth has a surprisingly weak relationship with fertility, and is predictive of total fertility rate only in Africa. Age at first birth is also unrelated to contraceptive usage. Contraceptive usage, especially modern contraceptive usage, predicts reduced fertility is most global regions, with the notable exception of Europe. Since global fertility rates are so low, and largely unrelated to age at first birth, these results suggest that reduced fertility has been achieved through increased interbirth intervals or by earlier age at last birth. This will be the subject of future inquiries.

References

Anderson, Kermyt G., and Bobbi S. Low. 2003. Nonmarital first births and women's life histories. In *The Biodemography of Human Reproduction and Fertility*, J. Rodgers and H.P. Kohler, eds., pp. 57-86. Boston: Kluwer Academic Publishers.

Bongaarts, John. 1978. A framework for analyzing the proximate determinants of fertility. *Population and Development Review* 4(1): 105–132.

Bongaarts, John. 2015. Modeling the fertility impact of the proximate determinants: Time for a tune-up. *Demographic Research* 33(19): 535-559.

CIA World Factbook. 2017. https://www.cia.gov/library/publications/the-world-factbook/

Cleland, John. 2009. Contraception in historical and global perspective. *Best Practice & Research Clinical Obstetrics & Gynaecology* 23(2):165-76.

Colleran, Heidi, & Kristin Snopkowski. 2018. Variation in wealth and educational drivers of fertility decline across 45 countries. *Population Ecology* 60:155-169. https://doi.org/10.1007/s10144-018-0626-5

Lam, David. 2011. How the world survived the population bomb: Lessons from 50 years of extraordinary demographic history. *Demography* 48:1231–1262.

Manuelli, Rodolfo E., and Ananth Seshadri. 2009. Explaining international fertility differences. *Quarterly Journal of Economics* 124(2):771-807.

Morgan, S. Philip. 2003. Is low fertility a twenty-first-century demographic crisis? *Demography* 40(4):589-603.

Morgan, S. Philip, and Miles G. Taylor. 2006. Low fertility at the turn of the twenty-first century. *Annual Review of Sociology* 32:375-399.

Population Reference Bureau. 2017. https://www.prb.org/2017-world-population-data-sheet/

Singh, Susheela, Lisa Remez, Gilda Sedgh, Lorraine Kwok, and Tsuyoshi Onda. 2018. *Abortion Worldwide 2017: Uneven Progress and Unequal Access*. New York: Guttmacher Institute.

Tsui, Amy O., Win Brown, Qingfeng Li. 2017. *Contraceptive Practice in Sub-Saharan Africa*. Population and Development Review 43:166-191.

United Nations. 2013. *World Fertility Report 2012*. Department of Economic and Social Affairs, Population Division.

United Nations. 2017a. *World Contraceptive Use 2017*. Department of Economic and Social Affairs, Population Division. (POP/DB/CP/Rev2017).

United Nations. 2017b. *World Fertility Data 2017*. Department of Economic and Social Affairs, Population Division. (POP/DB/Fert/Rev2017).

Van Bavel, J. 2013. The world population explosion: causes, backgrounds and projections for the future. *Facts, Views & Vision in ObGyn*, *5*(4), 281–291.

Fig 1. Total fertility rate by age at first birth, by global region

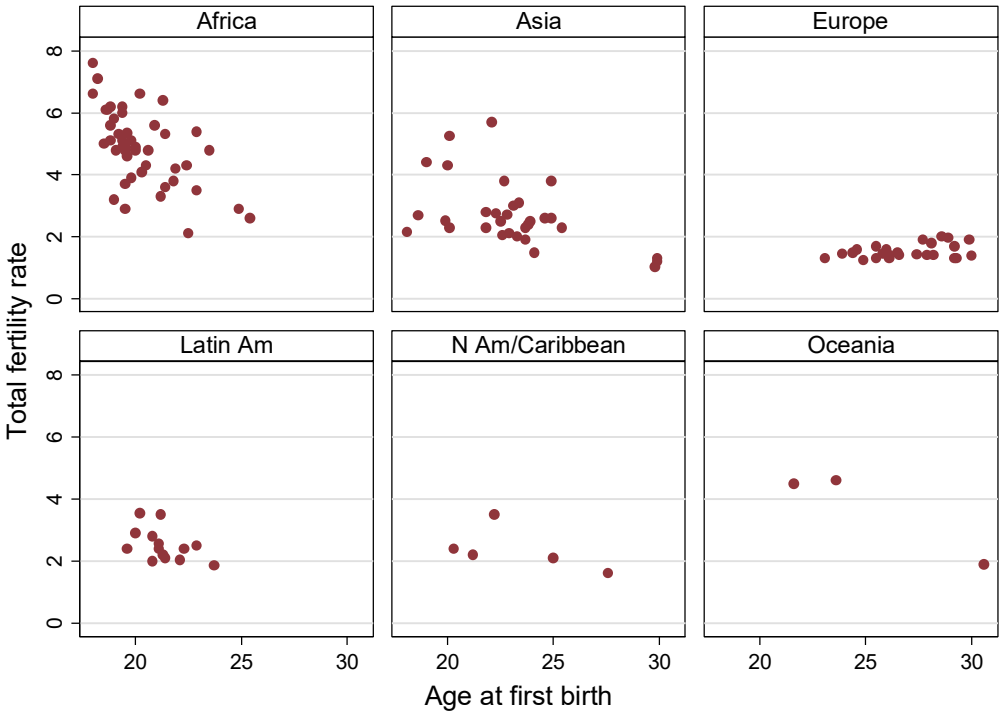

Fig 2. Total fertility rate by percent using traditional and modern contraception, by region

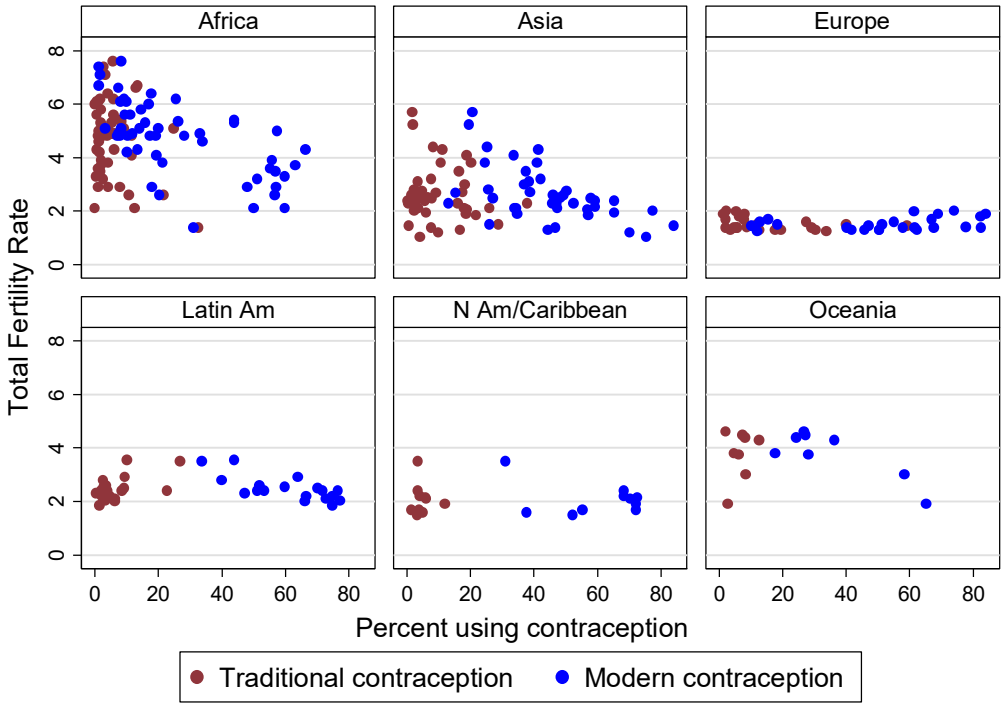

Fig 3. Age at first birth by percent using traditional and modern contraception, by region

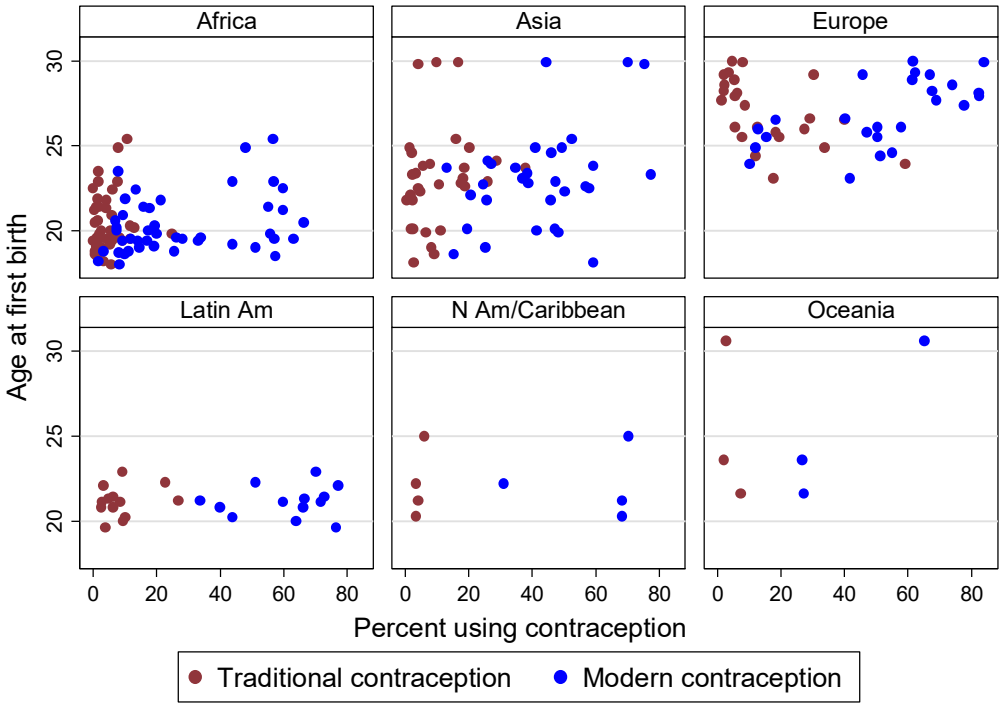

Table 1. Descriptive statistics for age at first birth, fertility, and contraceptive usage, by global region

	Africa		**Asia**		**Europe**		**Latin Am**		**N Am/ Caribb**		**Oceania**	
	Mean (SD)	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*
Age at first birth (years)	20.75 (1.86)	45	21.53 (2.81)	31	27.43 (2.27)	25	21.71 (0.74)	14	25.01 (1.40)	5	30.32 (1.85)	3
Total Fertility Rate	4.89 (1.35)	53	2.20 (0.75)	42	1.59 (0.24)	25	2.23 (0.35)	19	2.09 (0.30)	11	2.58 (1.19)	8
ASFR 20-24	218.28 (59.50)	49	141.92 (65.56)	40	68.84 (27.09)	25	141.57 (36.38)	17	118.77 (38.74)	9	174.81 (56.36)	8
ASFR 35-39	159.17 (51.03)	50	73.53 (47.82)	40	37.53 (16.13)	25	60.93 (25.31)	17	51.79 (37.60)	9	116.20 (37.50)	8
Any modern contraception	27.55 (20.41)	52	59.42 (19.38)	41	61.42 (14.44)	25	68.13 (10.89)	18	69.06 (7.44)	10	54.13 (19.14)	8
Any traditional contraception	4.91 (4.44)	52	6.21 (6.52)	41	9.30 (9.69)	24	5.89 (5.70)	18	5.75 (1.21)	10	4.17 (2.64)	8

Note: means are weighted for population size

Table 2. Prevalence (%) of specific contraceptive methods, by region

		Africa		**Asia**		**Europe**		**Latin Am**		**N Am/ Caribb**		**Oceania**	
		Mean	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Modern contraception													
	Female sterilization	1.68	49	**22.42**	40	4.19	22	**26.27**	19	**20.73**	11	5.36	8
	IUD	**3.57**	47	**16.63**	41	**11.15**	24	6.02	19	5.33	11	4.15	7
	Pill	**8.34**	52	6.11	41	**23.32**	24	**15.75**	19	**18.14**	11	**18.56**	8
	Condom (male)	2.02	51	**7.76**	41	**18.50**	25	**9.77**	19	**15.39**	11	**10.60**	8
	Injectable	**9.49**	52	5.73	36	0.80	14	7.01	17	1.05	11	3.31	8
	Male sterilization	0.04	53	2.12	42	3.83	25	2.79	19	9.61	11	**9.32**	8
Traditional contraception													
	Withdrawal	1.57	48	3.44	38	8.05	21	2.78	17	7.14	9	1.66	8
	Rhythm	2.38	50	2.53	40	3.00	19	3.15	17	1.80	10	1.79	8

Table 3. Pearson correlation coefficients between fertility and contraception variables

	AFB	TFR	ASFR 20-24	ASFR 35-39	Modern contr	Trad contr
Age at first birth (years)	1					
Total Fertility Rate	-0.7848	1				
ASFR 20-24	-0.8153	0.8884	1			
ASFR 35-39	-0.6466	0.9253	0.7620	1		
Any modern contraception	0.4382	-0.6274	-0.5808	-0.6186	1	
Any traditional contraception	0.3298	-0.2806	-0.2337	-0.2983	-0.1118	1

all $p < 0.01$ except traditional and modern contraception ($p = 0.16$)

Table 4. Mixed glm models of TFR and AFR, predicted by contraception

	AFB			**TFR**			**ASFR 20-24**			**ASFR 35-39**		
	Coef.	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*
Per capita Gross National Income (logged)	1.119	0.186	0.000	-0.397	0.067	0.000	-27.992	3.474	0.000	-9.865	2.811	0.000
Percent using modern contraception	0.012	0.010	0.257	-0.030	0.004	0.000	-0.758	0.204	0.000	-1.422	0.168	0.000
Percent using traditional contraception	0.036	0.019	0.065	-0.044	0.008	0.000	-0.922	0.378	0.015	-1.986	0.319	0.000
Intercept	12.914	1.600	0.000	8.064	0.549	0.000	429.072	28.471	0.000	253.202	22.679	0.000
N	112			136			129			129		
Wald chi-sq	56.19			170.05			132.36			148.37		
p	0.000			0.000			0.000			0.000		

Table 5. Mixed glm models of TFR, predicted by AFB & contraception

	TFR			**ASFR 20-24**			**ASFR 35-39**		
	Coef.	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*
Per capita Gross National Income (logged)	-0.269	0.090	0.003	-16.152	4.375	0.000	-9.489	4.012	0.018
Age at first birth	-0.048	0.039	0.219	-9.377	1.706	0.000	1.917	1.745	0.272
Percent using modern contraception	-0.029	0.004	0.000	-0.765	0.209	0.000	-1.517	0.198	0.000
Percent using traditional contraception	-0.041	0.008	0.000	-0.813	0.388	0.036	-2.171	0.368	0.000
Intercept	8.052	0.763	0.000	543.451	27.195	0.000	211.941	32.705	0.000
N	112			108			108		
Wald chi-sq	126.5			285.72			109.67		
p	0.000			0.000			0.000		

Table 6. Mixed glm models of TFR and ASFR, predicted by AFB, by region

	Africa			**Asia**			**Europe**			**Latin Am**		
A. TFR	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*			
Per capita Gross National Income (logged)	-0.547	0.130	0.000	-0.278	0.136	0.041	0.159	0.094	0.090	-0.185	0.178	0.299
Age at first birth	-0.187	0.061	0.002	0.022	0.064	0.728	-0.024	0.043	0.584	-0.097	0.114	0.397
Percent using modern contraception	-0.025	0.006	0.000	-0.043	0.009	0.000	-0.001	0.004	0.734	-0.023	0.007	0.000
Percent using traditional contraception	0.021	0.021	0.320	-0.047	0.015	0.002	-0.002	0.005	0.679	0.007	0.014	0.618
Intercept	13.10	1.21	0.000	6.76	1.13	0.000	0.72	0.86	0.403	7.53	1.68	0.000
N	42			28			22			13		
Wald chi-sq	125.81			40.85			8.41			35.90		
p	0.000			0.000			0.078			0.000		
	Africa			**Asia**			**Europe**			**Latin Am**		
B. ASFR 20-24	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*			
Per capita Gross National Income (logged)	-21.797	5.934	0.000	-25.172	8.404	0.003	-2.367	6.581	0.719	1.139	12.197	0.926
Age at first birth	-15.335	2.735	0.000	-0.515	3.875	0.894	-9.276	3.024	0.002	-15.466	7.860	0.049
Percent using modern contraception	-0.328	0.250	0.189	-1.903	0.544	0.000	0.417	0.254	0.101	-1.414	0.471	0.003
Percent using traditional contraception	0.258	0.955	0.787	-0.626	0.917	0.495	0.556	0.332	0.094	0.659	0.979	0.501
Intercept	695.65	55.26	0.000	455.47	69.37	0.000	309.62	60.38	0.000	548.89	117.54	0.000
N	39			26			22			13		
Wald chi-sq	93.95			36.32			34.63			29.51		
p	0.000			0.000			0.000			0.000		
	Africa			**Asia**			**Europe**			**Latin Am**		
C. ASFR 35-39	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*	*Coef.*	*Std. err.*	*p*			
Per capita Gross National Income (logged)	-20.688	6.147	0.001	-9.196	6.888	0.182	11.375	5.006	0.023	-3.884	6.957	0.577
Age at first birth	0.274	2.833	0.923	3.556	3.176	0.263	2.376	2.300	0.302	-8.190	4.483	0.068
Percent using modern contraception	-1.391	0.259	0.000	-2.313	0.446	0.000	-0.263	0.193	0.173	-0.888	0.268	0.001
Percent using traditional contraception	0.488	0.989	0.622	-3.060	0.752	0.000	-0.187	0.253	0.459	1.849	0.558	0.001
Intercept	336.19	57.24	0.000	198.04	56.86	0.000	-120.30	45.93	0.009	307.61	67.04	0.000
N	39			26			22			13		
Wald chi-sq	79.22			38.39			30.04			76.78		
p	0.000			0.000			0.000			0.000		